F-BRE Project # 3074

DECEMBER MONTHLY PROGRESS REPORT
MONTANA DOT "PERFORMANCE PREDICTION MODELS"

To:	**Jon Watson, MDT**
	Susan Sillick, MDT
Agency:	**Fugro-BRE**
MDT Contract No.:	**HWY-30604-DT**
Performance Period:	**Through December 2002**
Prepared By:	**Brian Killingsworth**
Date Prepared:	**January 06, 2003**

1.0 CURRENT MONTH WORK ACTIVITIES AND ACCOMPLISHMENTS

Task 1 – Literature Review
Complete. A draft memorandum summarizing the models to be considered within this project was submitted to the Department in October 2001. This memorandum will be updated when the calibration and validation of the 2002 Design Guide distress prediction models is made available.

Task 2 – Review of MT DOT Pavement-Related Data
Complete. However, Fugro-BRE will continue to monitor the LTPP database and update any missing data on the test sections with time.

The project team received the hardcopies of the MDT LTPP materials testing data for the SPS-1 and SPS-9A sections that was conducted by PRI under contract HWY-306477-DT. This data will be entered into the calibration database for immediate use. However, it would appear that there are some data elements required by the SPS-1 and SPS-9A materials sampling and testing plans that are not present in the data that was received. Personnel at Fugro-BRE, Inc. have reviewed the data to determine which elements are not available. The following lists the missing information:

SPS – 1

- Tests on PATB Layer – Complete
- Tests on ATB Layer – Missing AG05 (Fine agg. Particle shape)
- Tests on AC Surface layer – Missing test AG05 (Fine agg. Particle shape)

SPS – 9

Superpave aggregate and binder tests on HMA surface layer materials

- Aggregate tests – missing tests on section 1

Superpave mixture design tests to be performed on HMA surface layer materials from test sections 300901 and 300903

- Missing results on section 01

Tests to be performed on surface materials from test section 300902

- Gyratory Compaction @ 7%AV – 8 samples instead of 32
- Missing 3 BSG tests
- Missing AC04 – (asphalt content – extraction)

- Missing AG04 – (extracted aggregate gradation)
- Missing AC03 – (max. sp. Gr.)
- Missing all volumetric calculations

Quality Control related Tests on compacted specimen from test sections 300901 and 300903
- Gyratory compaction @ N max – 3 instead of 6.

Laboratory tests on cores from test sections.
- Only interval E results available.

Mr. Killingsworth and Mr. Von Quintus will determine which elements will be required for the calibration exercise and inform MDT during the next reporting period.

Task 3 – Establish the Experimental Factorials
Complete.

Task 4 – Develop Work Plan for Monitoring and Testing
Complete. The long-term monitoring plan will be revised after the initial analyses of the data are complete under Tasks 6 and 7.

Task 5 – Presentation of Work Plan to MDT
Complete.

Task 6 – Implement Work Plan – Data Collection
On-going activities. We are still in the process of testing the materials gathered from the additional 10 field sites. It was expected that all of the testing was going to be completed by the fall; however the testing subcontractors have been much slower than expected. We have worked out the testing and scheduling issues with the subcontractors and will have the information necessary to complete the initial calibration demonstration of Task 7 by mid-February.

Unbound Bases and Subgrades (Subcontractor – Fugro, Houston, TX): The objective for testing the unbound materials is to obtain repeated load resilient modulus (M_r) for each unbound base and subgrade material that was sampled. Testing was completed at the optimum moisture content; therefore, the moisture-density relationship for each unbound material was determined prior to M_r testing. Once the optimum moisture content was determined, sample preparation for the Mr testing was completed. Each sample was tested in accordance with the LTPP protocol and the results recorded.

As reported last month, there were three sites wherein the base layer did not have enough material to mold the appropriate height to diameter ratio specimens. Therefore, additional material that was gathered from immediately below the base is being added to the base material to get enough material for the proper height to diameter ratio. Testing is currently underway and the results will be assessed as soon as they are transmitted to us and will be included in the next progress report.

The data that is currently in hand was fit using the “universal” resilient modulus model that is being incorporated into the AASHTO 2002 Pavement Design Guide. The form of the universal model is as follows:

$$M_r = k_1 P_a \left(\frac{\Theta}{P_a}\right)^{k_2} \left(\frac{\lambda_{oct}}{P_a}\right)^{k_3}$$

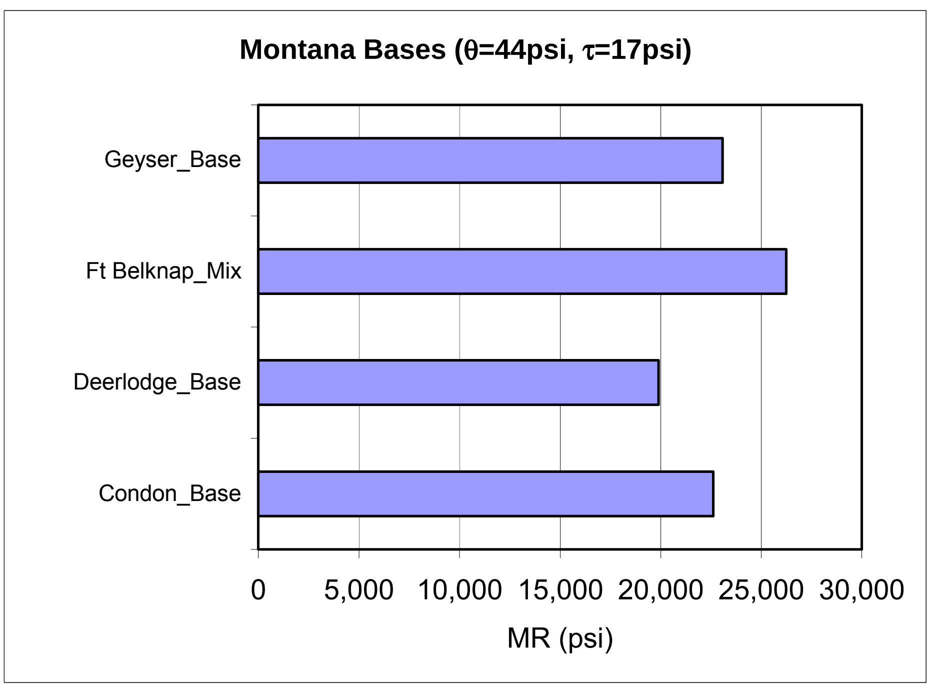
where:

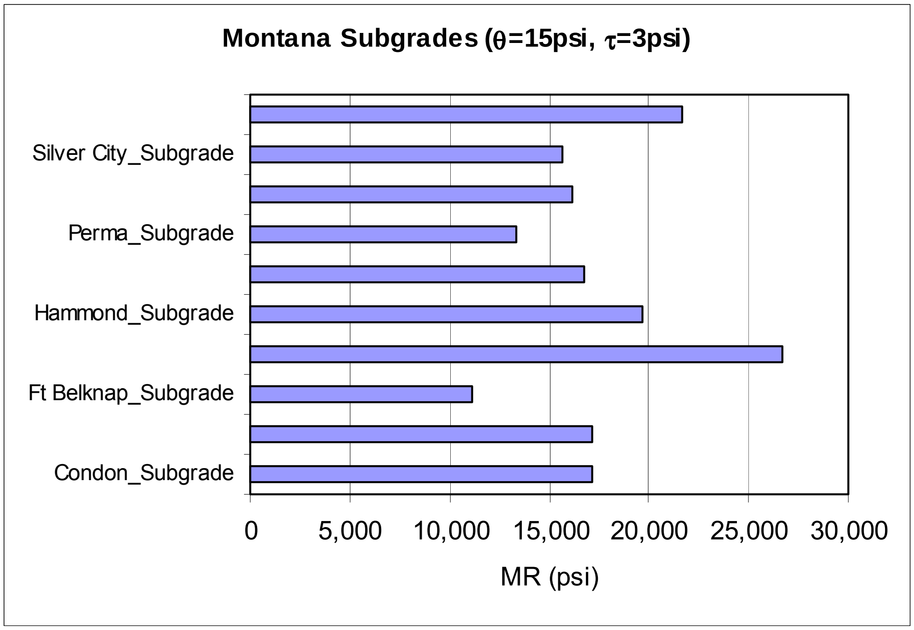
M_r = resilient modulus
P_a = atmospheric pressure
Θ = bulk stress
λ_{oct} = octahedral shear stress
k_1, k_2, k_3 = material and physical property parameters

The results of fitting the data are shown in the following table:

Material	n	k_1	k_2	k_3	R^2
Condon_Base	15	1,235	0.548	-0.497	0.90
Condon_Subgrade	15	1,568	1.007	-1.689	0.97
Deerlodge_Base	15	995	0.655	-0.533	0.89
Derlodge_Subgrade	15	1,134	0.346	0.128	0.81
Ft Belknap_Subgrade	15	632	0.450	0.926	0.94
Ft Belknap_Mix	15	1,776	0.563	-0.796	0.93
Geyser_Base	15	1,172	0.599	-0.474	0.96
Geyser_Subgrade	15	1,911	0.433	-0.317	0.96
Hammond_Subgrade	13	2,669	0.764	-3.796	0.84
Lavina_Subgrade	14	1,825	1.130	-2.659	0.94
Perma_Subgrade	15	1,435	0.555	-2.539	0.94
Roundup_Subgrade	15	1,350	0.455	-1.160	0.93
Silver City_Subgrade	15	1,548	0.491	-2.087	0.96
Wolf Pt_Subgrade	12	1,765	0.332	-1.000	0.71

The resilient modulus at a typical state of stress for a base and subgrade are shown in the following figures.





In addition, plots of the actual versus predicted resilient modulus using the universal model for each of the materials is graphically depicted in Appendix A.

HMA Cores (Subcontractor – Advanced Asphalt Technologies, Sterling, VA): There are two objectives for testing the HMA cores. The first is to obtain data for the Superpave Thermal Fracture analysis. This requires low temperature creep and strength data at three temperatures. The second objective is to obtain resilient modulus data to verify stiffness values obtained from the Witczak dynamic modulus equation. Based on these two objectives an initial testing scheme was suggested; however, that testing plan was going to require too much time. Therefore, an alternative testing regime was proposed and accepted for each supplemental site:

For each section, the testing will now be completed in this manner:

1. Based on air voids, split cores into two equal groups, one for Mr testing and one for low temperature testing.

2. Within each group, select three cores that span the air void range and perform Mr and low temperature creep testing at three temperatures on each core.

3. After those test results are reviewed and found to be suitable, split the subgroup into three groups of 2 specimens and conduct IDT strength tests including strain to failure at the temperatures performed for the Mr and low temperature creep tests.

In summary, for each section, three cores will be tested for Mr at three temperatures, and IDT strength with strain to failure will be obtained at the same temperatures as the Mr tests using 2 specimens per temperature. The same will be true for low temperature testing as well. Three cores will be tested for creep compliance, and IDT strength will be obtained at the same temperatures as the compliance tests using 2 specimens.

This provided the lowest cost and quickest approach to obtaining the data that is needed for the Task 7 calibration. It has been indicated that Mr testing will commence in early January and be completed in mid-February. The low temperature and creep testing will begin immediately following the Mr testing. An estimate on the duration of the low temperature testing will be made at the onset of that testing.

CTB Cores (Subcontractor – The University of Texas, Austin, TX): The objective for testing the CTB cores was to obtain the elastic modulus of the material. Five samples from the four sites that had CTB layers were sent to the testing subcontractor and they were requested to perform ASTM 469 on four of the specimens. One extra sample was provided from each site to determine the ultimate strength before running the elastic modulus tests. As required by the elastic modulus test protocol, the 6" diameter cores were to be reduced to 4" diameter specimens. However, some of the cores fell apart during the 4" coring process. These were the cores where the cement content was relatively low and hence had low bond strength among the aggregate particles.

Currently, there are sufficient extra cores to replace the ones that fell apart during the coring process. Moreover, Fugro-BRE, Inc. is providing the testing subcontractor with alternative coring methods such that the specimen integrity will be maintained and a testable core will be provided. The PI has requested that the re-coring and testing be completed as soon as possible.

Backcalculation of Deflections: The first round of deflection tests have been backcalculated and summarized. In addition, the second round of deflection testing has also been backcalculated utilizing the same pavement structure information as the round 1 data. The plots showing the results from rounds 1 and 2 are included in Appendix B. The table at the end of this section includes the average moduli and other statistics for each round of testing at the supplemental sites. In addition, graphical comparisons of the round 1 and 2 backcalculated moduli are included for review. Further review of this data will be completed by Mr. Von Quintus and Mr. Killingsworth to assess the reasonableness of some of the backcalculated moduli and determine which data will be included in the calibration database.

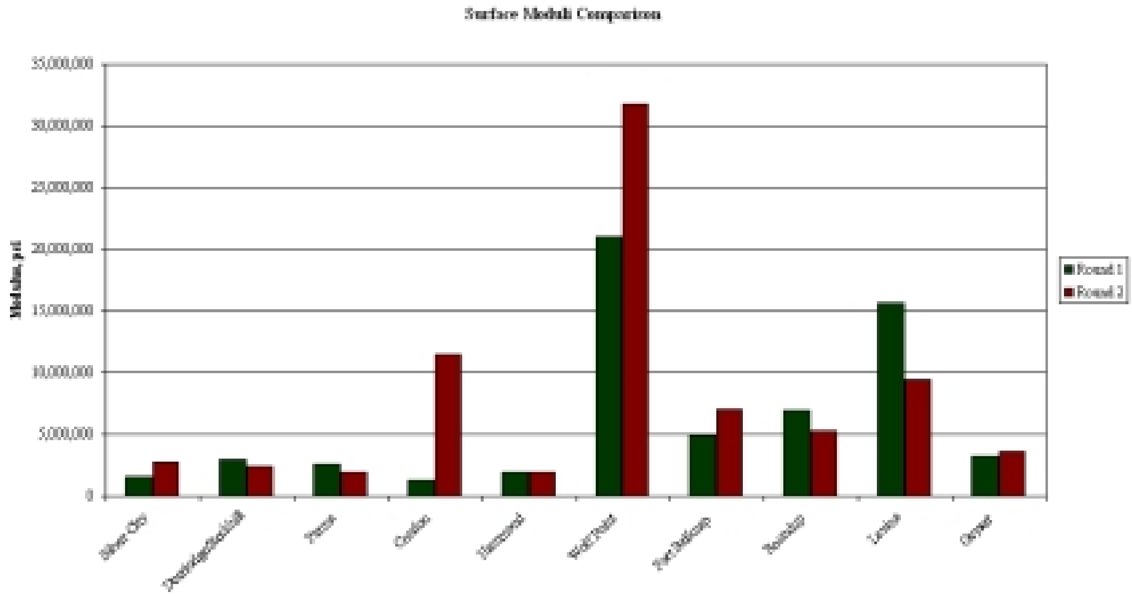
Superpave Supplemental Sites: The project team has discussed with MDT finding new pavement sections for use in the experimental plan. These sections are to be constructed with Superpave-designed hot mix and will be sampled by MDT and/or the project team during the time of construction. The purpose of adding these sections will be to incorporate pavements constructed with current MDT mixture design procedures. MDT personnel have also discussed the sampling requirements for each site with Dr. Tam and are working with other members of the project team to obtain some samples during this construction season. On August 15, 2002, MDT personnel conducted sampling at the Ft. Belknap site. This site has been overlaid with a leveling course and a surface course. The sampling included asphalt binder, aggregate stockpiles, and hot-mix directly in front of the paver.

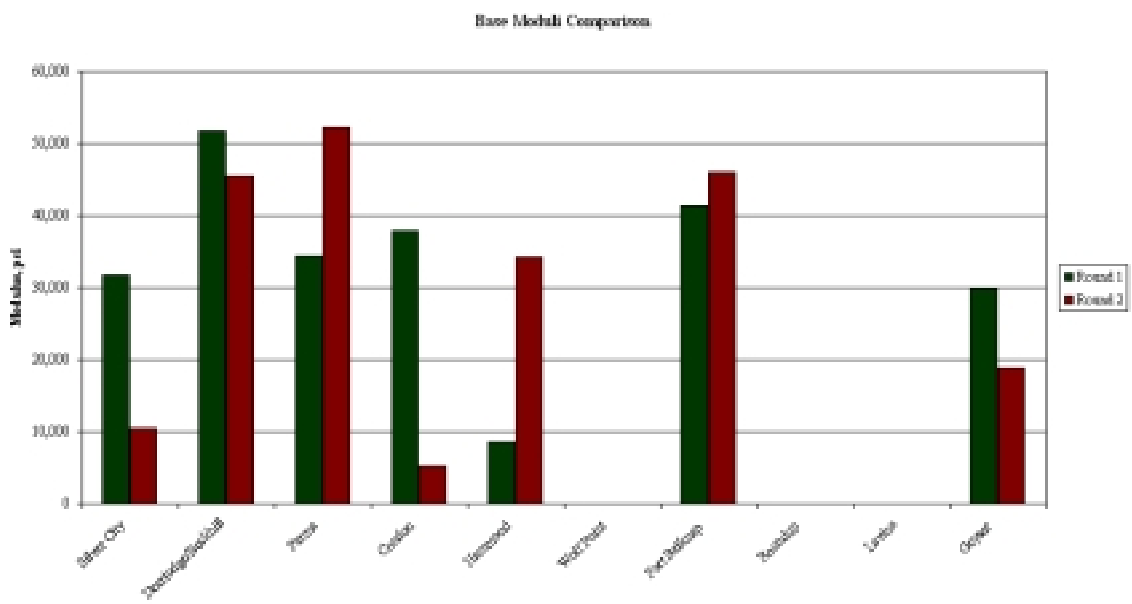
In addition, MDT personnel sampled subgrade and subbase materials from Vaughn N., and sampled subgrade from Lothair E. in late summer. Both sites were staked well away from any possible disturbance (both 3' lath and short stake) and GPS readings were taken at each location so that the sites could be easily identified. Other pavement layer sampling has been completed with the exception of the asphalt courses that will be placed next year. The Baum road site has also been included in the additional sites however, the PI is unclear as to what the status of sampling is at this site.

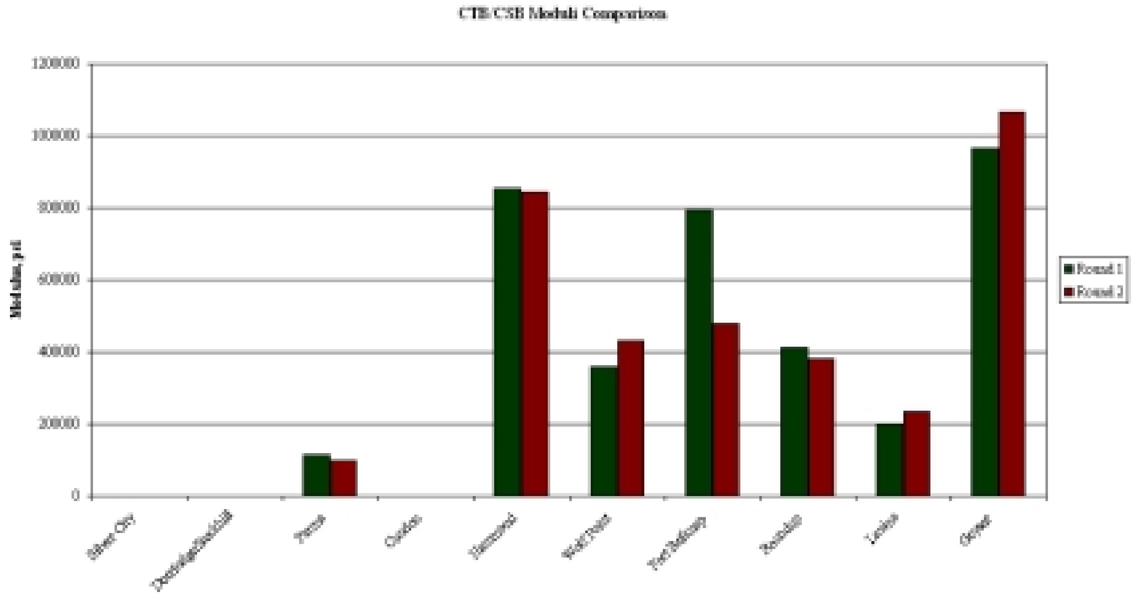
<u>Field Investigation Report:</u> A field investigation report has been completed by the project team and includes a summary of the distress surveys, field sampling results (cores, bores and other geotechnical information), FWD Deflections (round 1 only), and longitudinal profiles from each of the supplemental sites.

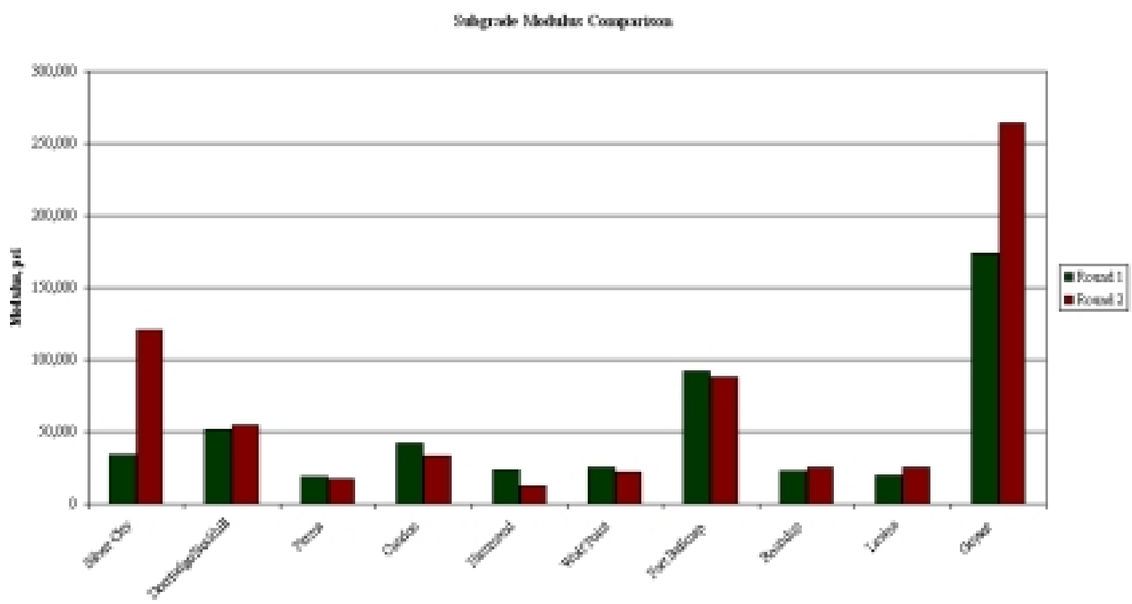
<u>Supplemental Data:</u> Fugro-BRE contacted Dr. Vince Janoo and obtained a copy of the seasonal data and draft report entitled "Performance of Montana Highway Pavements During Spring Thaw." This data will be used in analyzing the response and performance data that were monitored and obtained from other test sections.

Section ID	Layer Description	Thickness, (inches)	Round 1 Moduli, (psi)			Round 2 Moduli, (psi)		
			Average	Std. Dev.	COV, %	Average	Std. Dev.	COV, %
Silver City	ACP	4.9	1,596,163	332,542	21	2,777,825	1,556,171	56
	Base	7.0	31,799	19,915	63	10,397	16,139	155
	Subgrade	-	34,150	8,463	25	120,409	153,697	128
Deerlodge/Beckhill	ACP	4.3	2,981,496	911,689	31	2,371,957	645,492	27
	Pulverized	8.1	75,446	52,511	70	95,438	59,162	62
	Existing Base	33.1	51,696	33,473	65	45,504	26,650	59
	Subgrade	-	51,669	16,728	32	54,510	8,256	15
Perma	ACP	3.3	2,580,667	996,804	39	1,899,574	1,256,533	66
	CSB	4.1	115,515	87,704	76	96,885	89,261	92
	Base	6.0	34,441	26,007	76	52,154	113,743	218
	Subgrade	-	19,188	2,393	12	17,843	4,299	24
Condon	ACP	5.4	1,304,387	232,913	18	11,526,524	1,959,005	17
	Pulverized	9.0	34,154	11,978	35	13,862	2,999	22
	Base	24.1	37,865	15,255	40	5,291	574	11
	Subgrade	-	42,445	4,456	10	33,425	4,377	13
Hammond	ACP	3.9	1,944,509	2,358,620	121	1,905,818	2,091,541	110
	CSB	6.3	854,485	346,248	41	843,578	503,491	60
	Base	5.3	8,528	8,597	101	34,222	42,442	124
	Subgrade	-	23,659	32,250	136	12,574	4,529	36
Wolf Point	ACP	3.7	21,059,012	14,206,617	67	31,732,742	12,543,938	40
	CTB	19.8	360,282	184,041	51	431,996	230,821	53
	Subgrade	-	25,051	25,583	102	22,120	3,457	16
Fort Belknap	ACP	4.5	4,862,690	3,550,666	73	7,042,385	5,780,104	82
	CTB	7.5	793,717	791,142	100	478,577	658,415	138
	Base	39.0	41,401	18,292	44	46,101	32,469	70
	Subgrade	-	92,138	116,850	127	88,005	102,438	116
Roundup	ACP	4.3	6,988,455	3,870,889	55	5,298,000	3,391,156	64
	CTB	18.7	413,464	116,356	28	380,036	163,634	43
	Subgrade	-	23,195	3,659	16	25,221	3,693	15
Lavina	ACP	2.8	15,609,524	15,000,535	96	9,404,635	9,936,858	106
	CTB	15.2	200,227	147,158	73	233,601	155,195	66
	Subgrade	-	20,111	11,203	56	25,602	45,192	177
Geyser	ACP	4.1	3,269,303	2,253,217	69	3,596,607	7,466,006	208
	CSB	11.4	966,394	365,574	38	1,063,937	674,396	63
	Base	25.5	29,788	27,088	91	18,908	13,552	72
	Subgrade	-	173,938	358,302	206	264,321	371,561	141


Surface Moduli Comparison
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
Modulus, psi
Round 1
Round 2


Base Moduli Comparison
60,000
50,000
40,000
30,000
20,000
10,000
0
Modulus, psi
Round 1
Round 2


CTB/CSB Moduli Comparison
1200000
1000000
800000
600000
400000
200000
0
Modulus, psi
Round 1
Round 2


Subgrade Modulus Comparison
300,000
250,000
200,000
150,000
100,000
50,000
0
Modulus, psi
Round 1
Round 2
Silver City

Task 7 – Data Analyses and Calibration of Performance Prediction Models
The objectives of this task are to demonstrate the calibration technique required to develop and maintain the various model calibration coefficients that will be used by the department both now and in the future. As discussed with the MDT, four major distress types were considered in the experimental plan and thus require prediction models and calibration coefficients. These include fatigue cracking (both surface initiated and bottom initiated surface cracks), thermal cracking, rutting or permanent deformation, and ride quality.

The project team is currently awaiting release of the AASHTO 2002 Design Guide information, which is expected in the first half of 2003 before attempting any calibration of these models. However, the calibration technique (or the specific steps required to determine calibration coefficients) can still be demonstrated to MDT utilizing models similar in nature to the AASHTO 2002 Design Guide models. The project team is moving ahead with this demonstration portion of Task 7 with data obtained from the LTPP database and the supplemental sites.

Calibration Database Development: The initial steps required to populate the calibration and validation database have begun. The first step taken was to verify which LTPP data were missing since the last time it was checked. No significant changes in the available data were found. However, as noted in the write-up for Task 2, there are some data issues that need to be resolved prior to their inclusion into the database.

Also, the status of the additional LTPP sections outside, but surrounding, Montana were verified. Each of the sections was checked for sufficient data so that only those sections with adequate data are being utilized.

In addition, Structured Query Language (SQL) statements are being developed for extracting the data required for model calibration from the LTPP IMS. These SQL statements will be provided to MDT so that future calibration efforts utilizing updated LTPP data may be streamlined.

Environmental Data: Montana climatic data will be utilized in the calibration effort. Specifically, the AASHTO 2002 environmental database may be used and will include information for Montana and its surrounding regions. However, it is also recommended that MDT include additional years of environmental data (up to 20 years) to better quantify the expected environmental conditions. The project team will discuss the best alternative for obtaining this information and the appropriate method for incorporating this information in the calibration exercise and provide these recommendations to MDT.

Traffic Data: A review of all the LTPP traffic tables has been initiated. The completeness of the data will be documented and the need for additional traffic information will be assessed. Recommendations for the required traffic information have already been discussed among the project team and Mr. Von Quintus and Dr. Hallenbeck will continue gathering, reviewing and assessing this data, especially in light of the initial calibration effort currently underway.

Task 8 – Final Report and Presentation of Results
No activity.

2.0 PROBLEMS/RECOMMENDED SOLUTIONS

It has come to our attention that the Ft. Belknap supplemental site has already been overlaid. Since there are a limited number of supplemental sites, it is imperative that MDT attempt to maintain these sites as long as possible so that continued, long-term monitoring is feasible.

As mentioned in the preceding text, the supplemental site material testing is progressing at a slower rate than expected. Most of the issues have already been addressed and results have been transmitted or are expected in the next few weeks. The scheduling issues with AAT have been addressed and testing is underway.

No other problems were encountered during last month and none are anticipated next month.

3.0 NEXT MONTH'S WORK PLAN

The activities planned for next month are discussed below:

- Coordinate with Department personnel on an as-needed basis.
- Continue testing materials that are outstanding. This primarily includes the asphalt concrete cores taken from the supplemental sites.
- Continue analysis of all data collected at the LTPP and non-LTPP test sections.
- Continue with the initial calibration demonstration effort.

4.0 FINANCIAL STATUS

Following is a summary of the estimated expenses incurred during the months of June/July.

Cost Element	Previous Cumulative Cost, $	Current Expenditures, $	Cumulative Costs, $
Direct Labor	37,256	2,882	40,138
Overhead	53,275	4,121	57,397
Consultants/Subcontractors	7,615		7,615
ERES/ARA	5,901	0	5,901
Parsons-Brinkerhoff	8,527	0	8,527
SME	446	77	523
Dr. Matthew Witczak	0	0	0
Dr. Mark Hallenbeck	3,130	0	3,130
Travel	10,802	0	10,802
Testing	17,504	5,345	22,849
Other Direct Costs	3,109	5	3,114
Fee	14,757	1,243	16,000
Total Costs	162,323	13,673	175,996

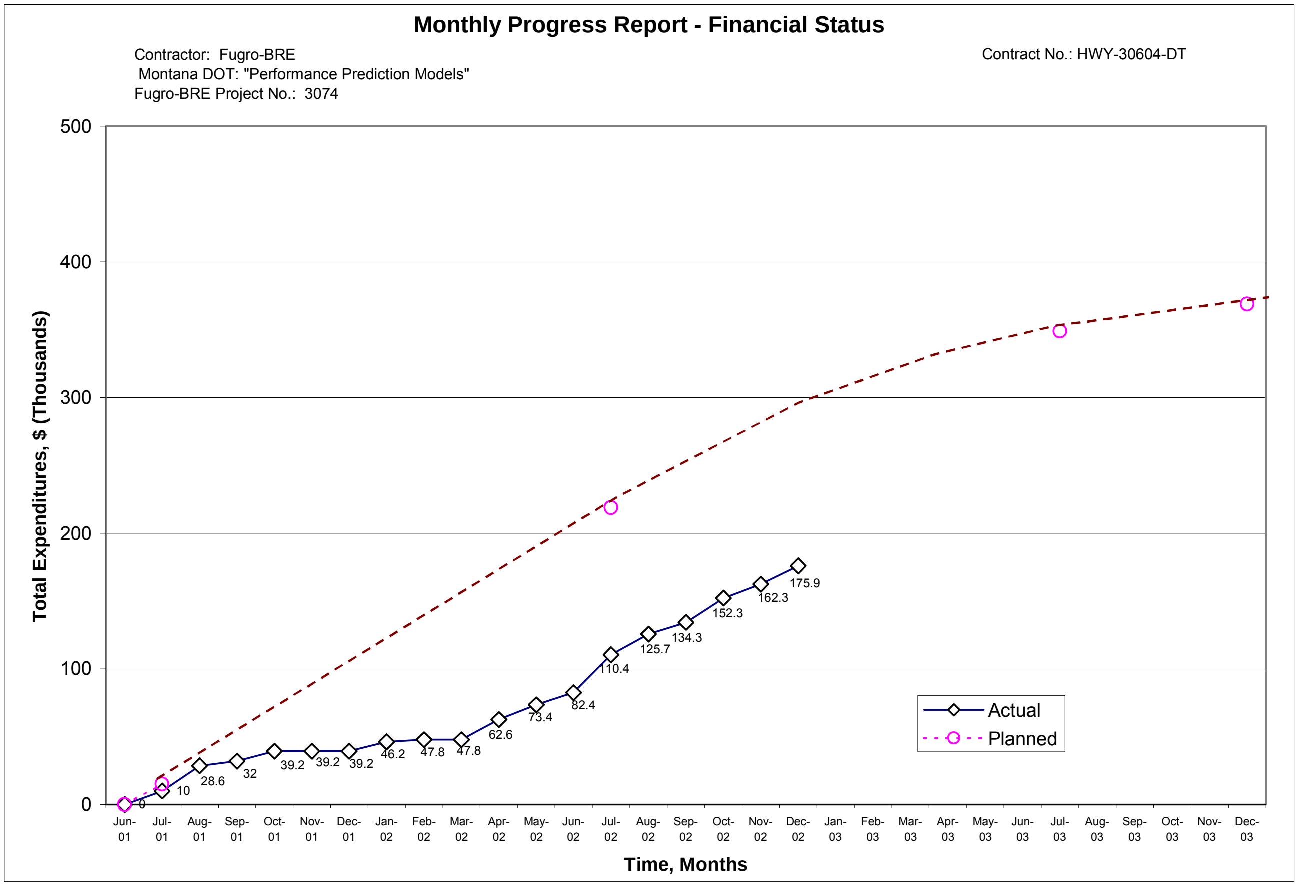
The following table provides a summary of the total expenditures by the Montana and FHWA fiscal years in comparison to the allocated funds for each fiscal year.

Montana DOT Fiscal Year				FHWA Fiscal Year			
Fiscal Year		Allocated Funds Cumulative, $	Expenditures Cumulative, $	Fiscal Year		Allocated Funds Cumulative, $	Expenditures Cumulative, $
6/1-6/30	2001	15,000	*0	6/1-9/30	2001	65,000	31,996
7/1-6/30	2002	218,969	82,420	10/1-9/30	2002	258,969	102,303
7/1-6/30	2003	348,969	93,576	10/1-9/30	2003	358,969	41,697
7/1-6/30	2004	388,969	---	10/1-9/30	2004	398,969	---
7/1-6/30	2005	428,969	---	10/1-9/30	2005	438,969	---
7/1-6/30	2006	498,969	---	10/1-9/30	2006	498,969	---
	TOTAL	498,969	175,996			498,969	175,996

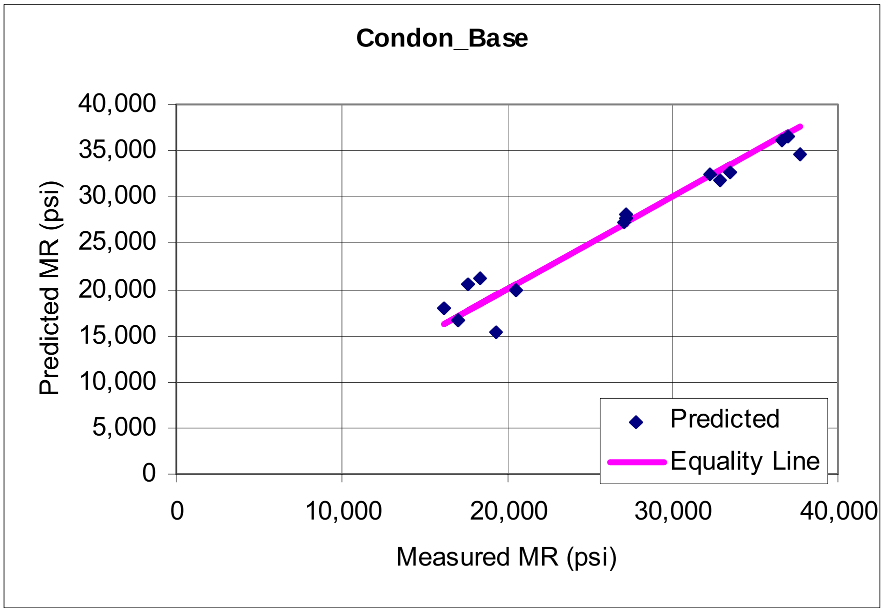
*June 2001 expenditures were combined with July 2001 expenditures.

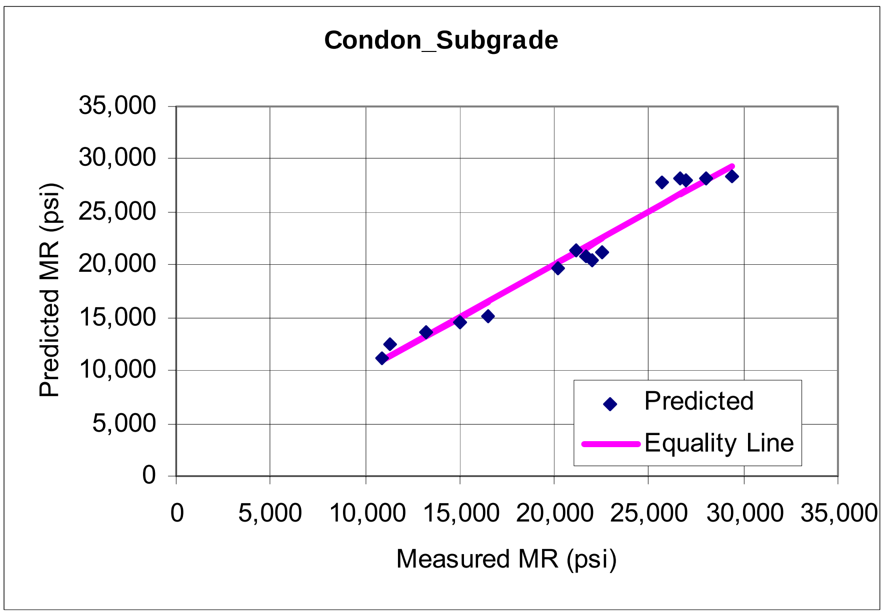
Accumulated expenses for the project, through the end of December, are represented graphically in the following chart. The financial chart of actual versus planned expenditures shows that the project team is billing less than expected. This difference is a result of postponing materials sampling to Spring 2002. We expect that the actual versus planned expenditures will become more equal in the coming months after the materials sampling and testing has been completed.

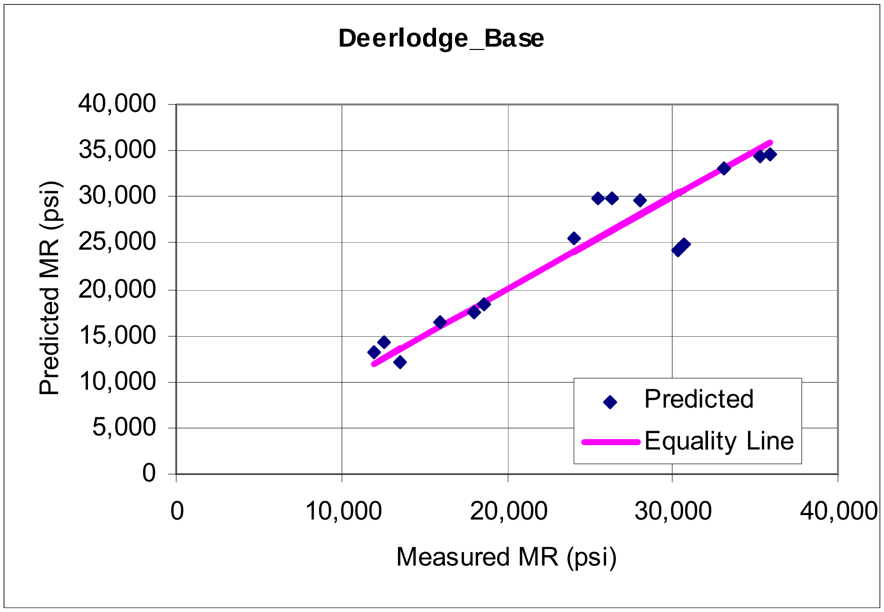
cc: Weng On Tam, Fugro-BRE
Harold Von Quintus, ARA/ERES

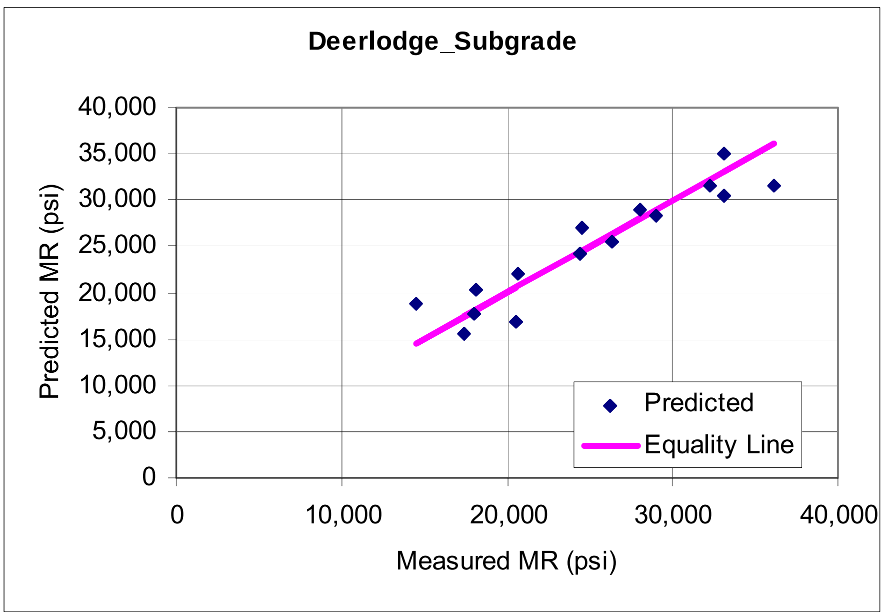

Monthly Progress Report - Financial Status
Contractor: Fugro-BRE
Montana DOT: "Performance Prediction Models"
Fugro-BRE Project No.: 3074
Contract No.: HWY-30604-DT
Total Expenditures, $ (Thousands)
Time, Months
Actual
Planned
0
10
28.6
32
39.2
39.2
39.2
46.2
47.8
47.8
62.6
73.4
82.4
110.4
125.7
134.3
152.3
162.3
175.9

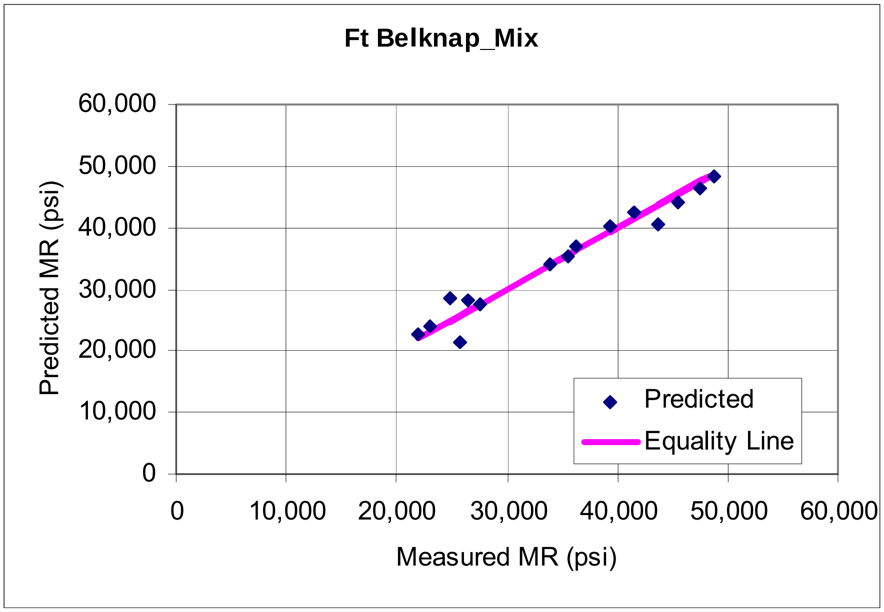
Appendix A –
Supplemental Sites:
Laboratory Determined Unbound Resilient Modulus (M_r)
Subgrade and Base Materials
Actual vs. Predicted M_r Utilizing the Universal Model

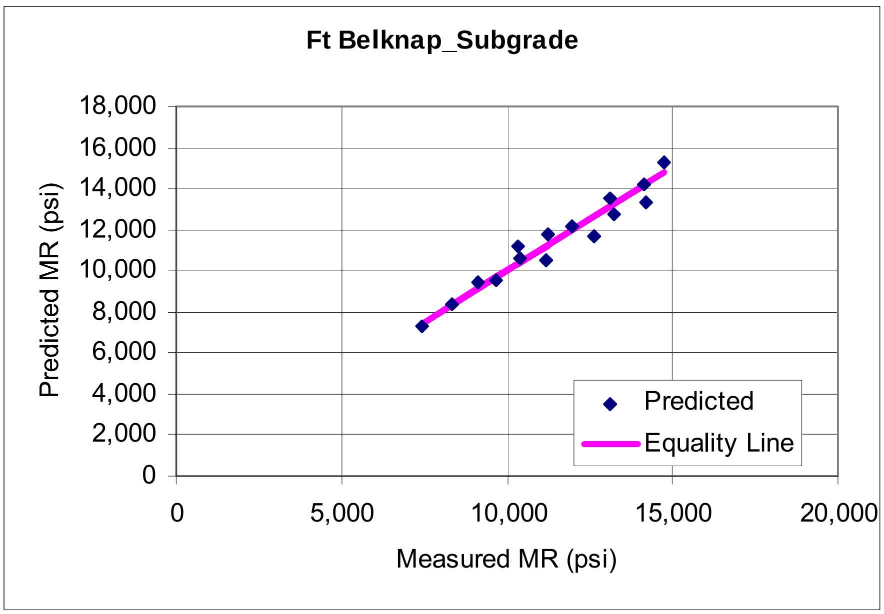

Condon_Base
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Predicted MR (psi)
0
10,000
20,000
30,000
40,000
Measured MR (psi)
Predicted
Equality Line

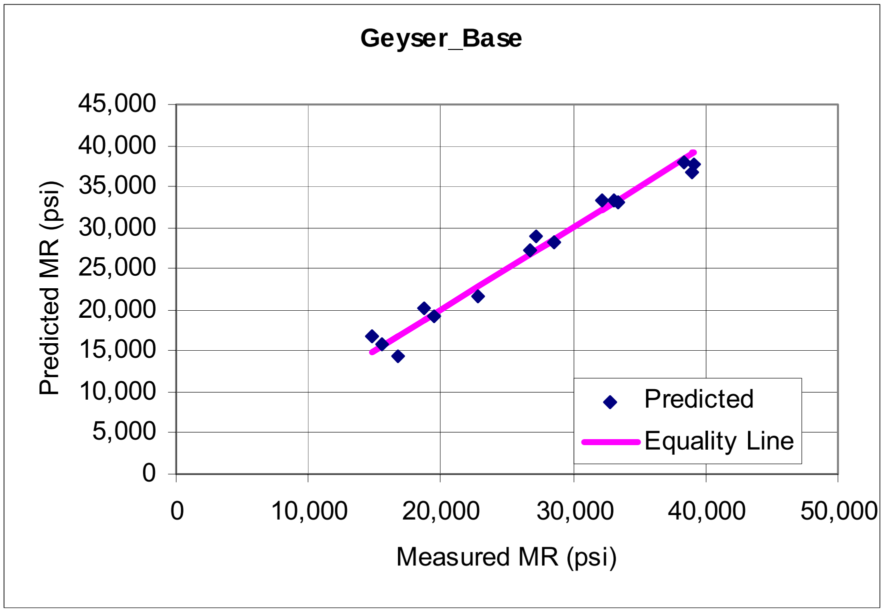

Condon_Subgrade
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Predicted MR (psi)
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Measured MR (psi)
Predicted
Equality Line

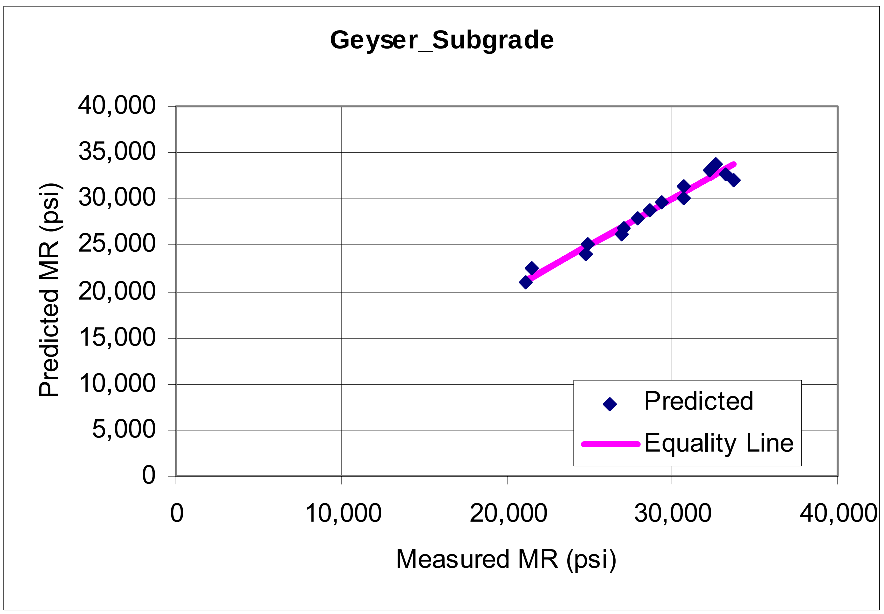

Deerlodge_Base
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Predicted MR (psi)
0
10,000
20,000
30,000
40,000
Measured MR (psi)
Predicted
Equality Line

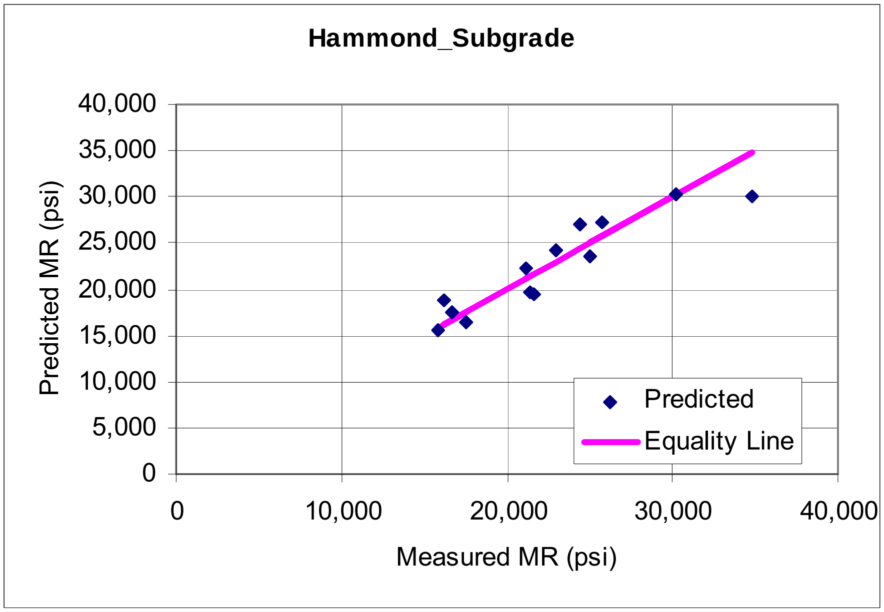

Deerlodge_Subgrade
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Predicted MR (psi)
0
10,000
20,000
30,000
40,000
Measured MR (psi)
Predicted
Equality Line

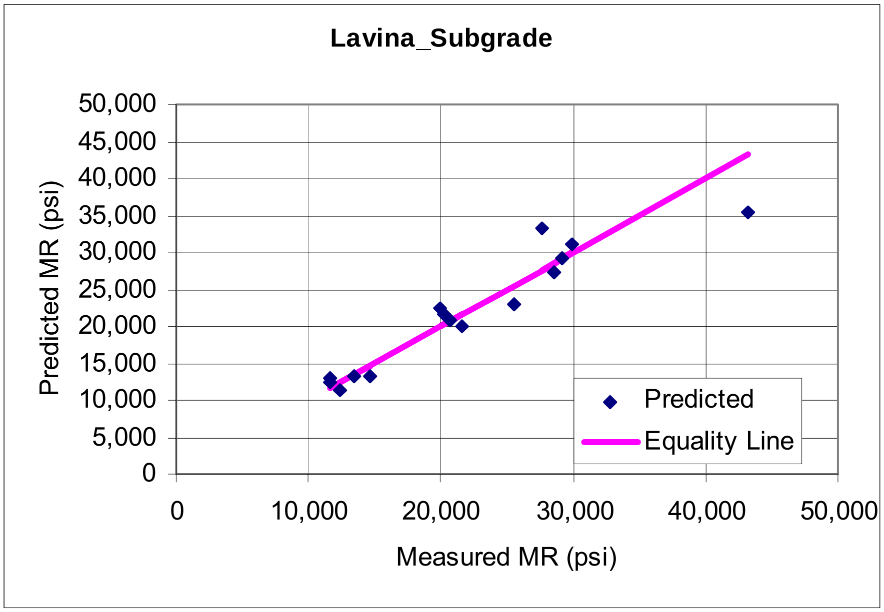

Ft Belknap_Mix
Predicted MR (psi)
60,000
50,000
40,000
30,000
20,000
10,000
0
0
10,000
20,000
30,000
40,000
50,000
60,000
Measured MR (psi)
Predicted
Equality Line


Ft Belknap_Subgrade
Predicted MR (psi)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
5,000
10,000
15,000
20,000
Measured MR (psi)
Predicted
Equality Line

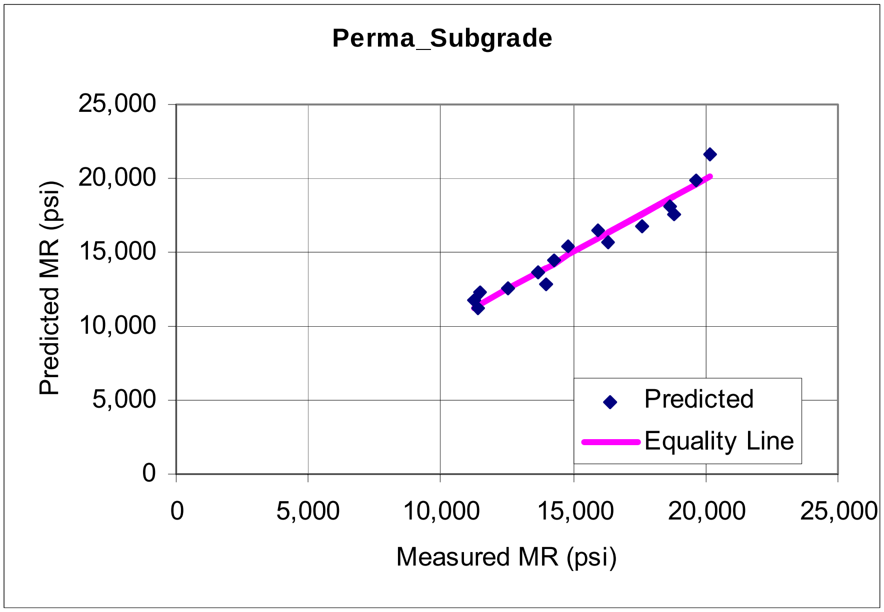

Geyser_Base
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Predicted MR (psi)
0
10,000
20,000
30,000
40,000
50,000
Measured MR (psi)
Predicted
Equality Line


Geyser_Subgrade
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Predicted MR (psi)
0
10,000
20,000
30,000
40,000
Measured MR (psi)
Predicted
Equality Line

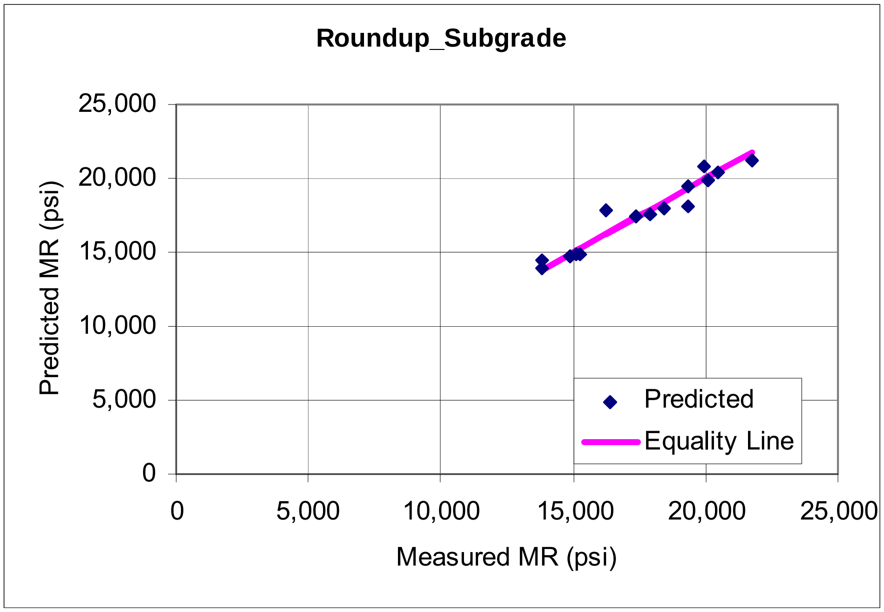

Hammond_Subgrade
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Predicted MR (psi)
0
10,000
20,000
30,000
40,000
Measured MR (psi)
Predicted
Equality Line



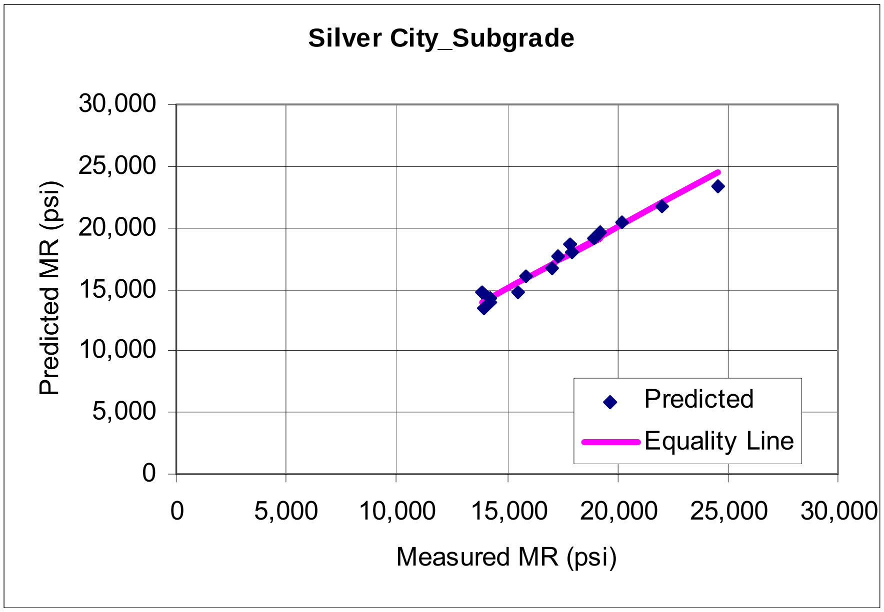
Lavina_Subgrade
Predicted MR (psi)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
10,000
20,000
30,000
40,000
50,000
Measured MR (psi)
Predicted
Equality Line

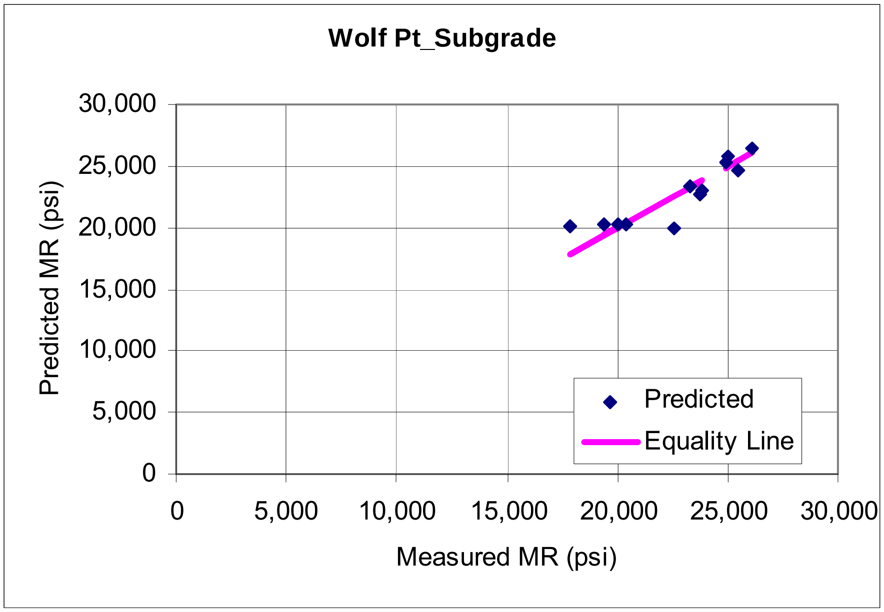


Perma_Subgrade
25,000
20,000
15,000
10,000
5,000
0
Predicted MR (psi)
0
5,000
10,000
15,000
20,000
25,000
Measured MR (psi)
Predicted
Equality Line



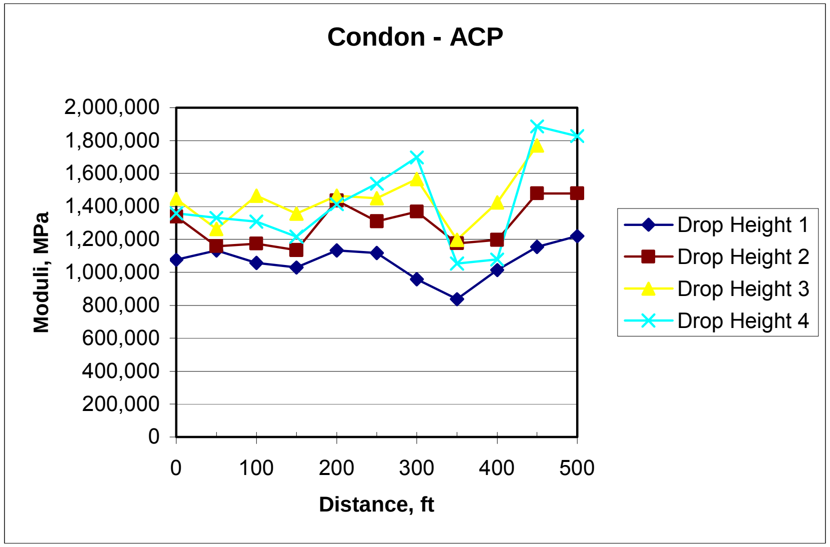
Roundup_Subgrade
25,000
20,000
15,000
10,000
5,000
0
Predicted MR (psi)
0
5,000
10,000
15,000
20,000
25,000
Measured MR (psi)
Predicted
Equality Line

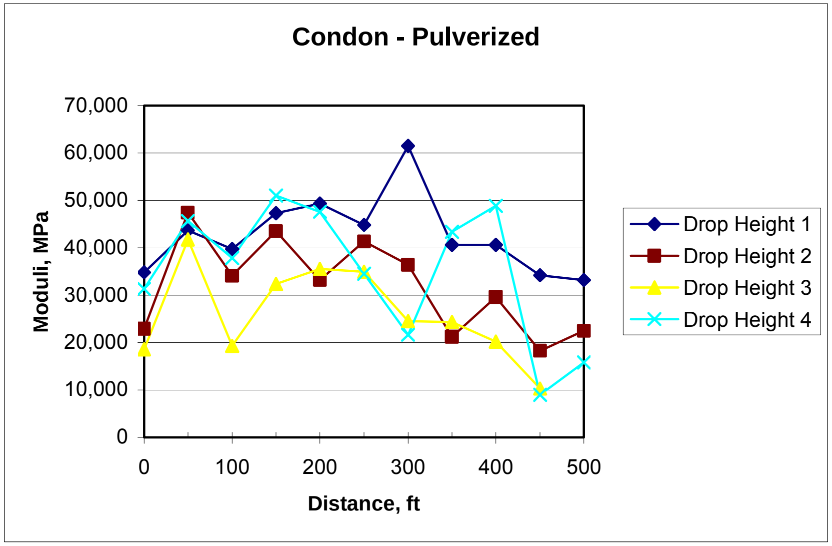

Silver City_Subgrade
Predicted MR (psi)
30,000
25,000
20,000
15,000
10,000
5,000
0
0
5,000
10,000
15,000
20,000
25,000
30,000
Measured MR (psi)
Predicted
Equality Line

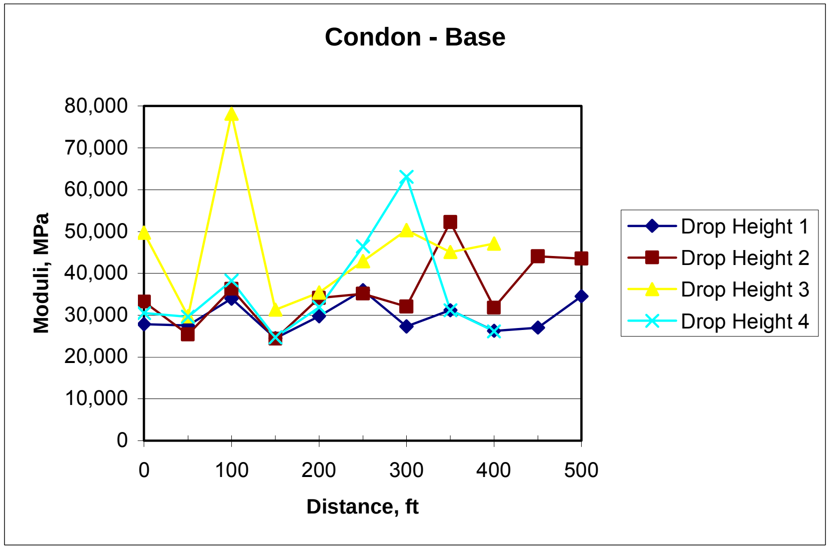

Wolf Pt_Subgrade
Predicted MR (psi)
30,000
25,000
20,000
15,000
10,000
5,000
0
0
5,000
10,000
15,000
20,000
25,000
30,000
Measured MR (psi)
Predicted
Equality Line

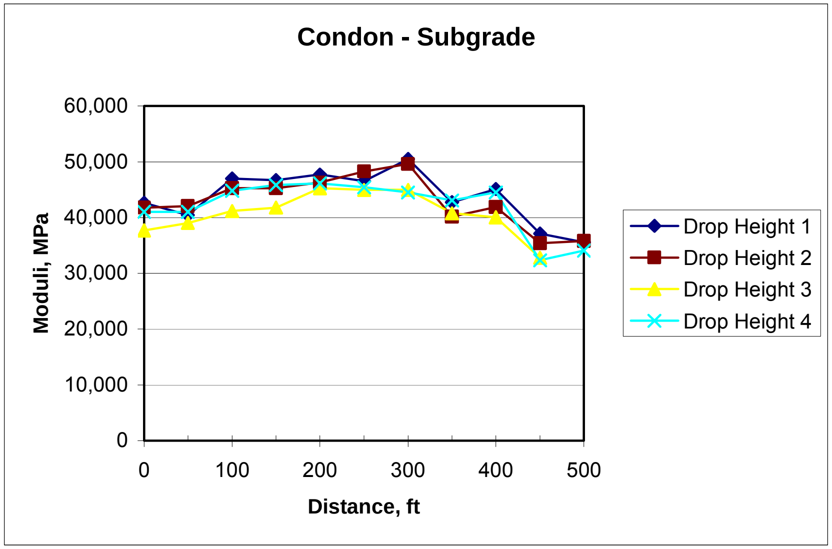
Appendix B –
Supplemental Sites:
Backcalculated Resilient Modulus Data
All Pavement Layers
Rounds 1 and 2

Round 1 Testing

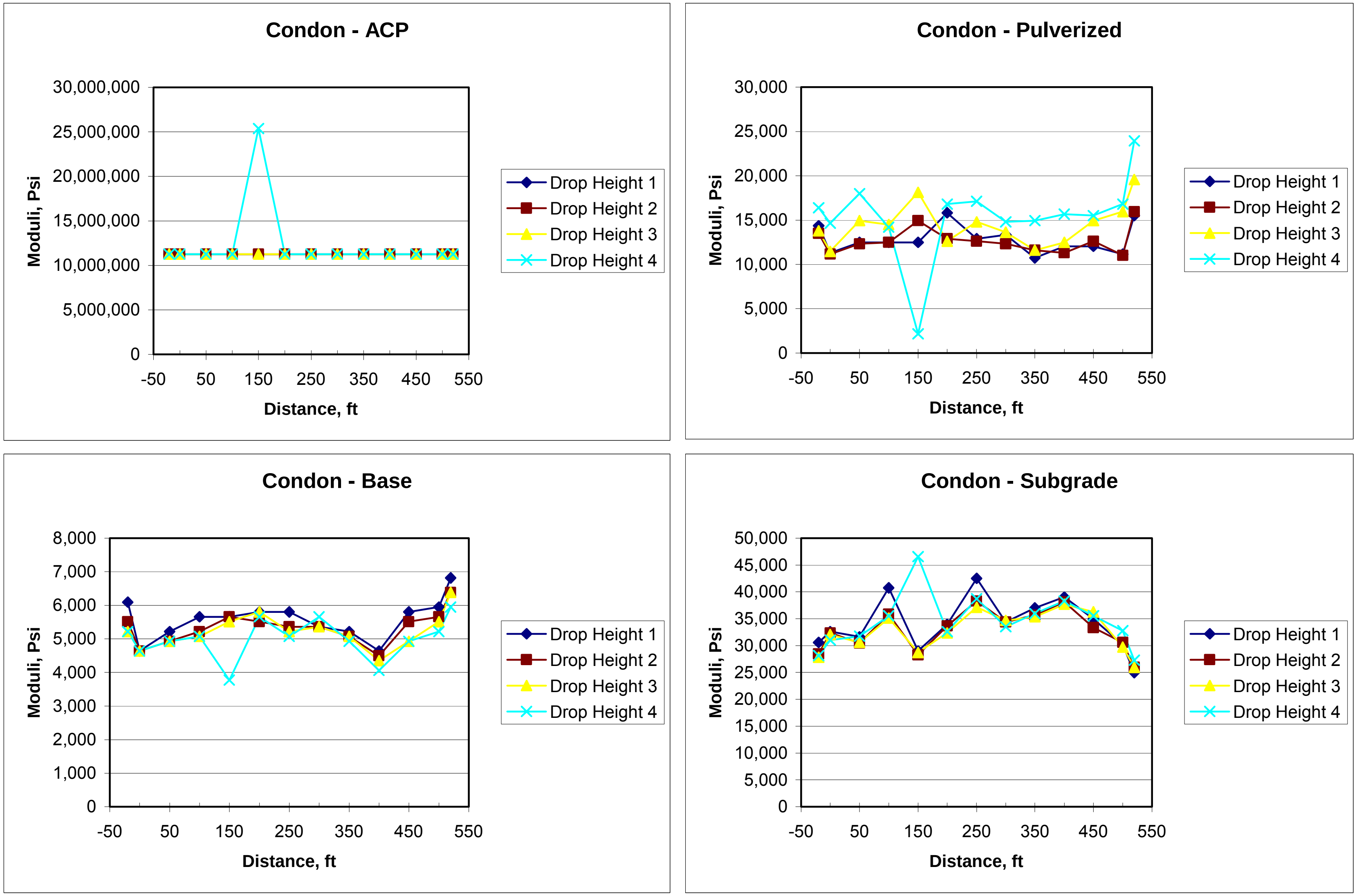




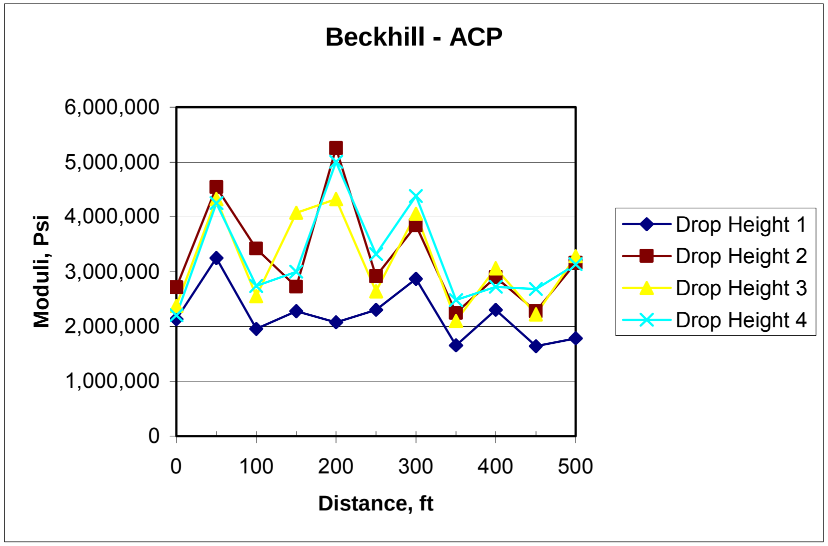


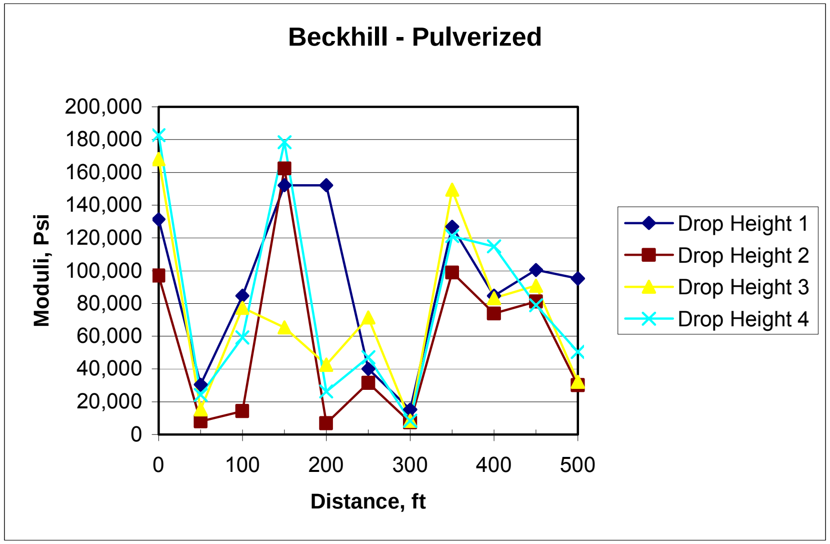


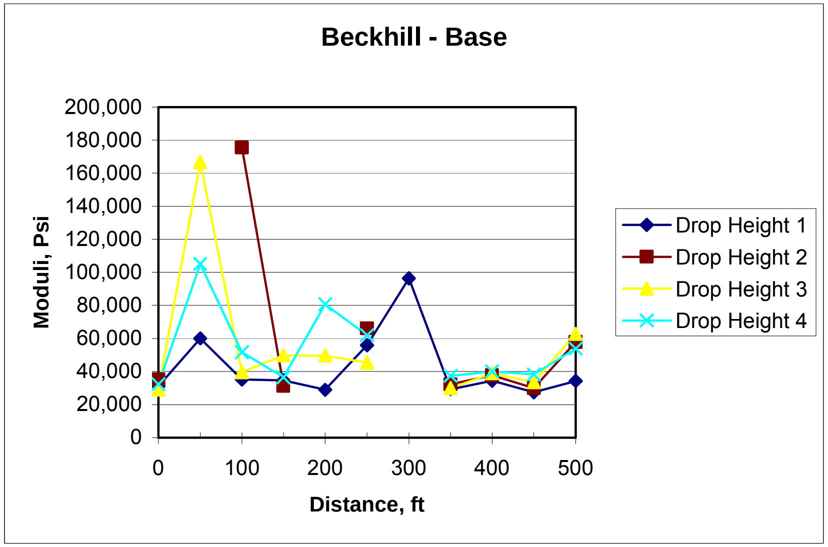
Round 2 Testing

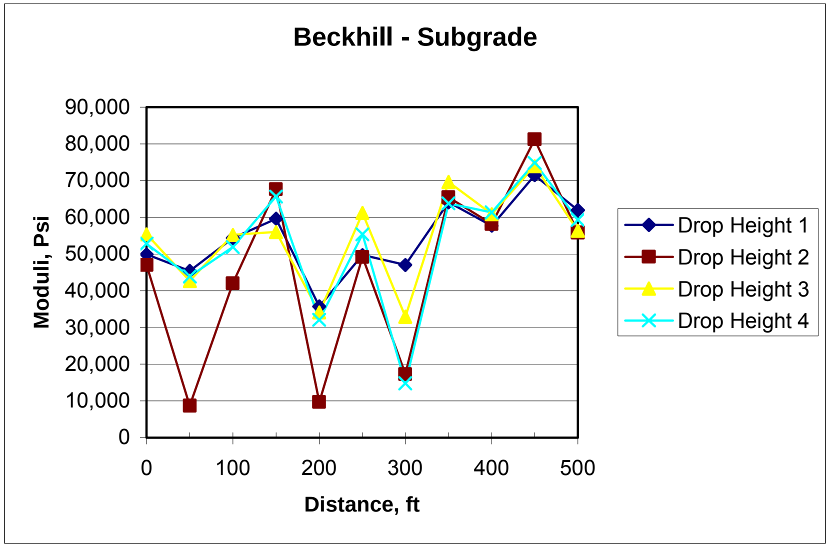


Round 1 Testing

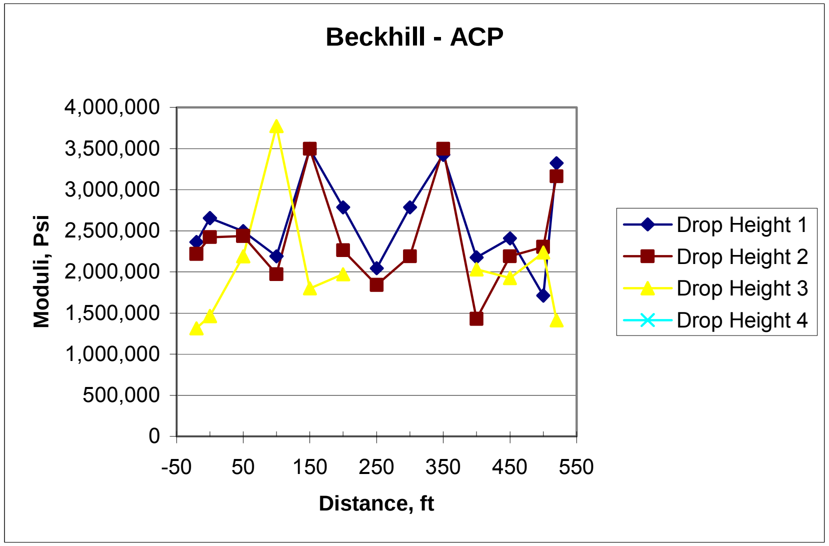


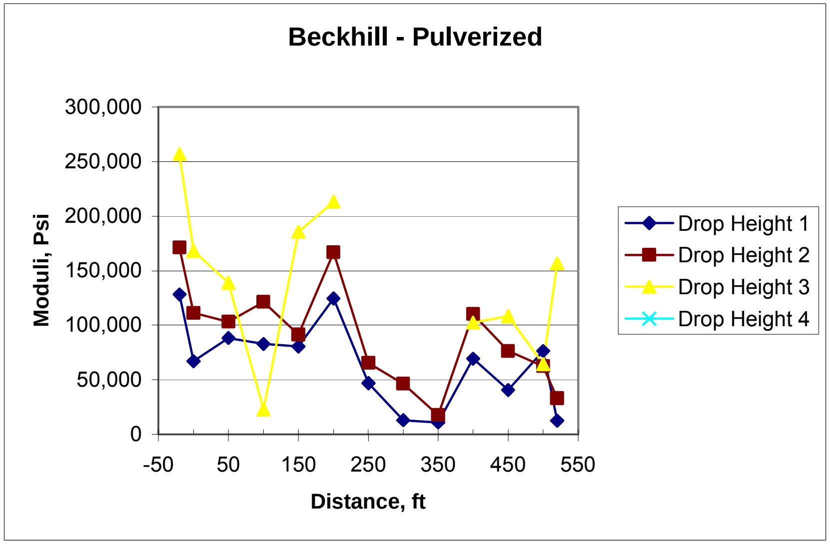


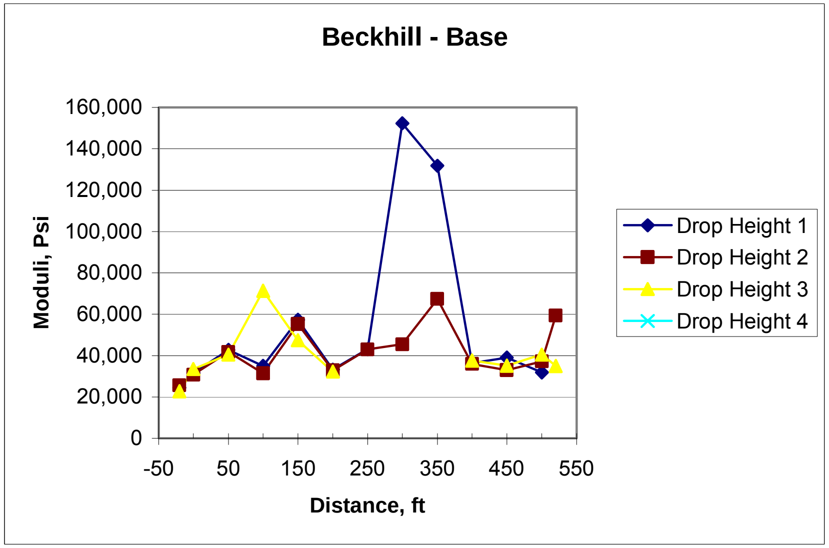


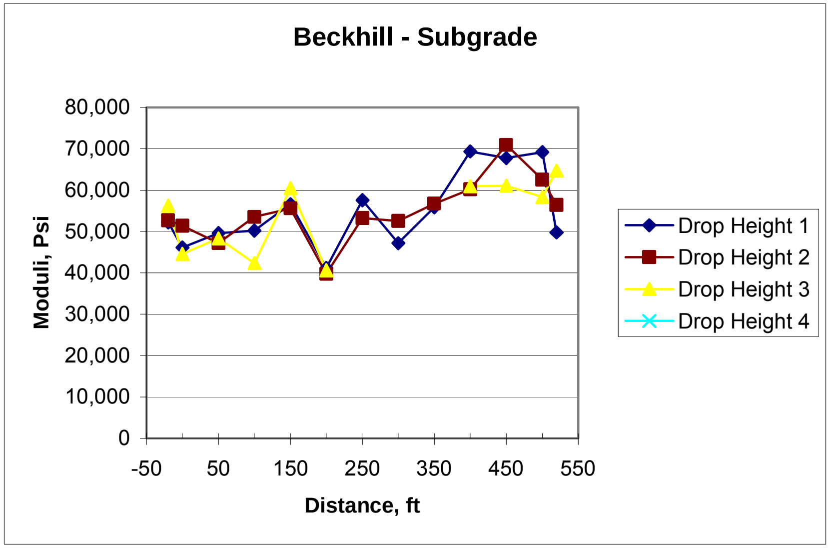


Round 2 Testing

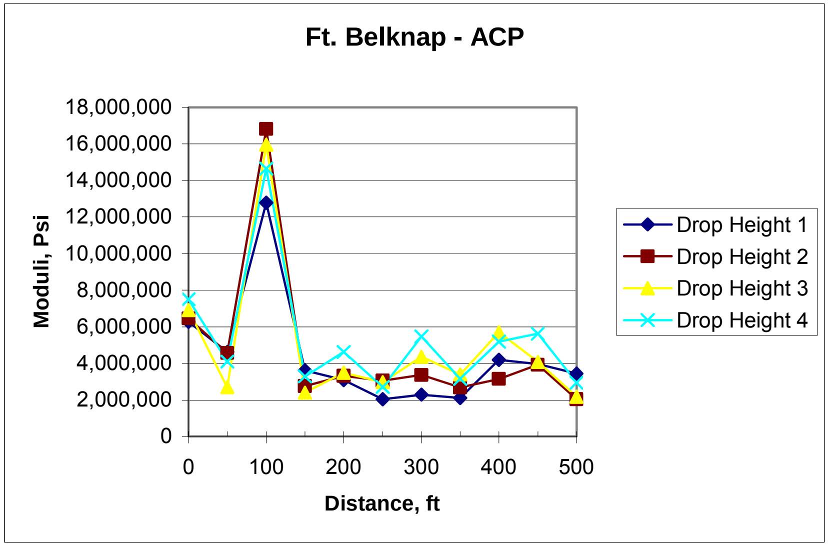


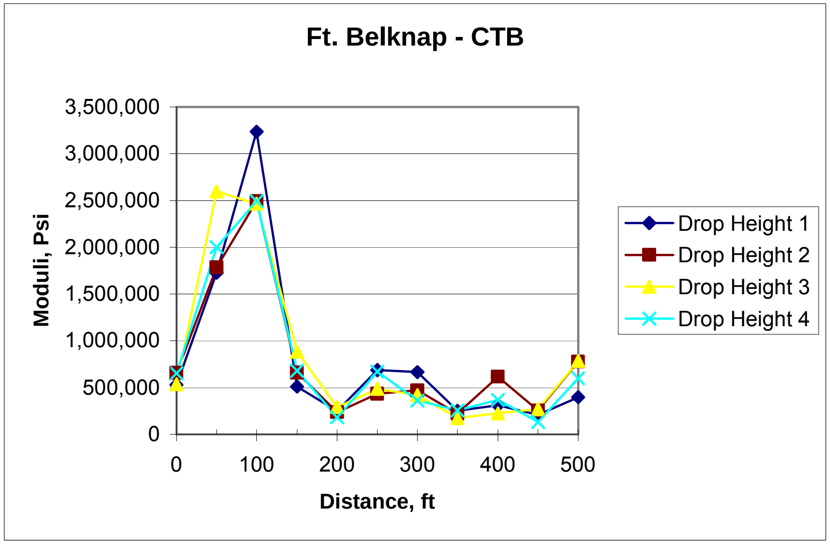


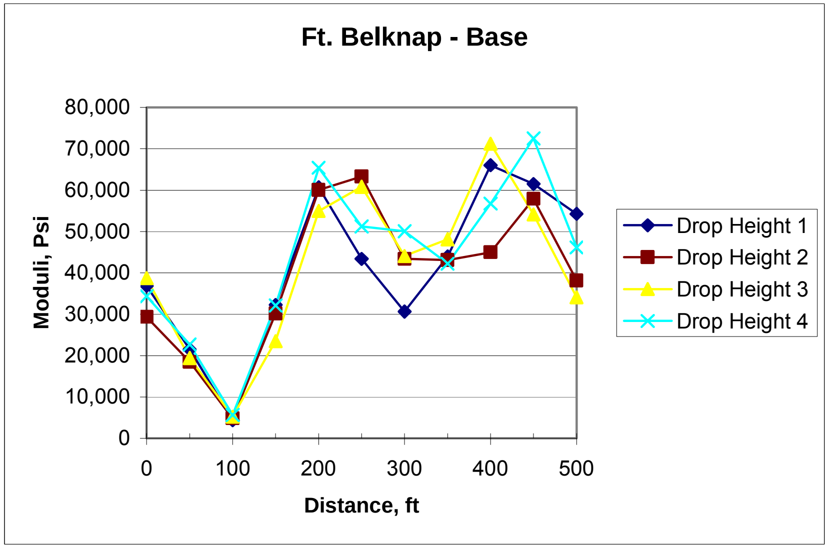


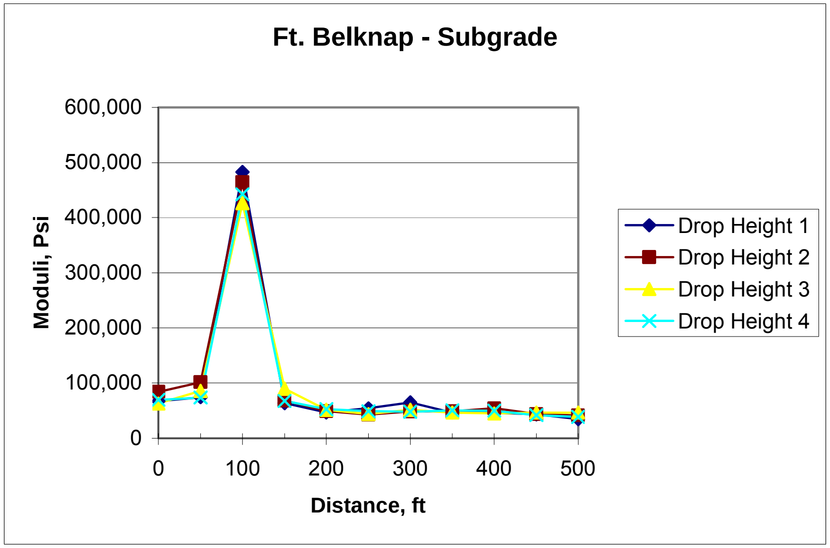


Round 1 Testing

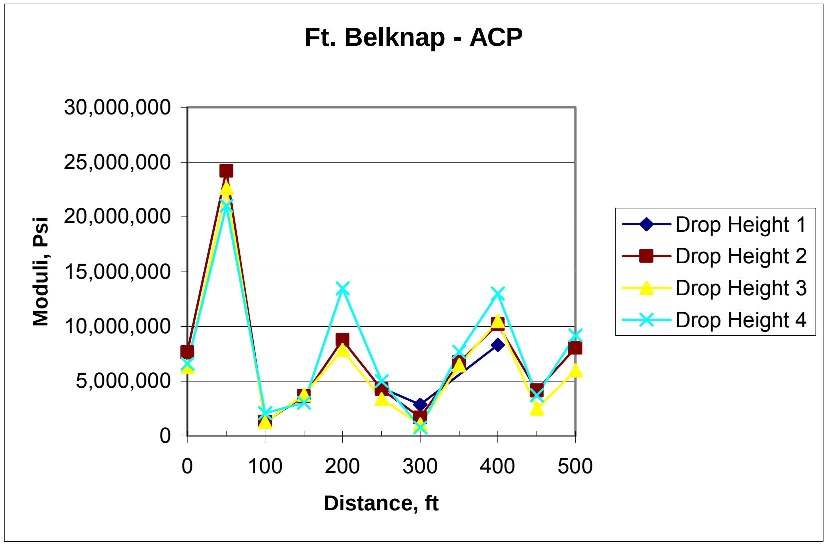


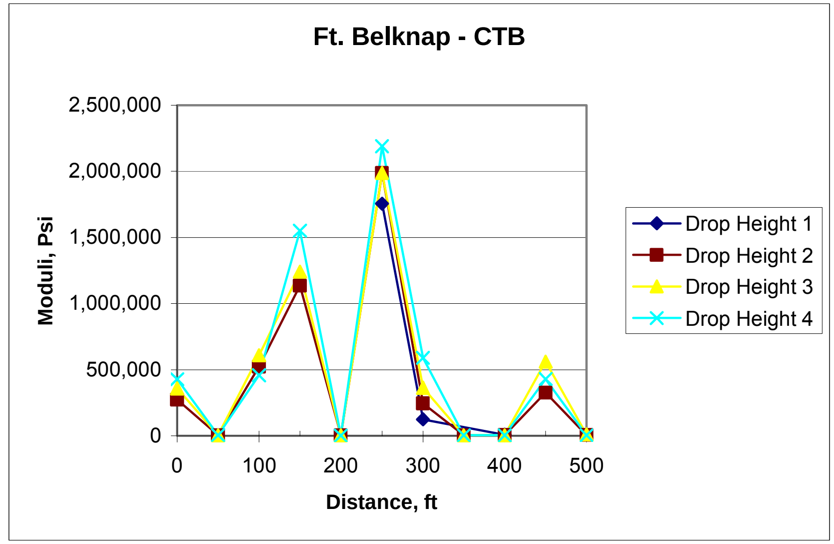


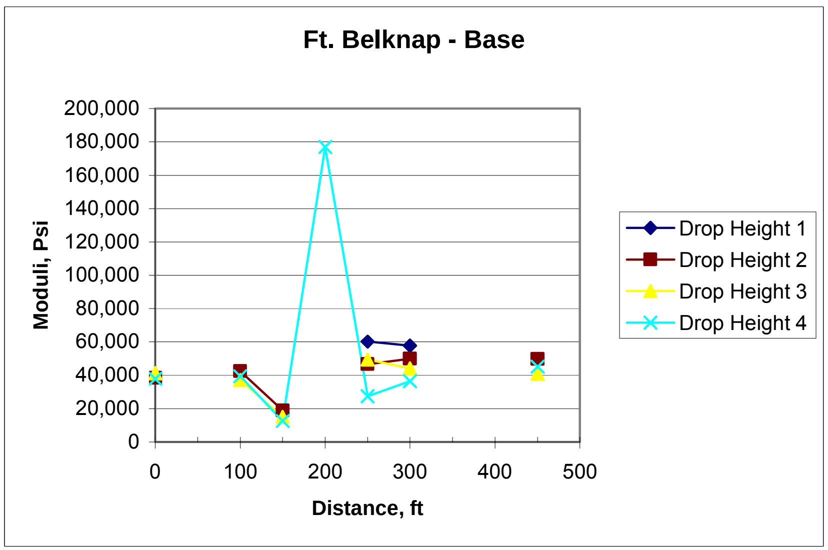


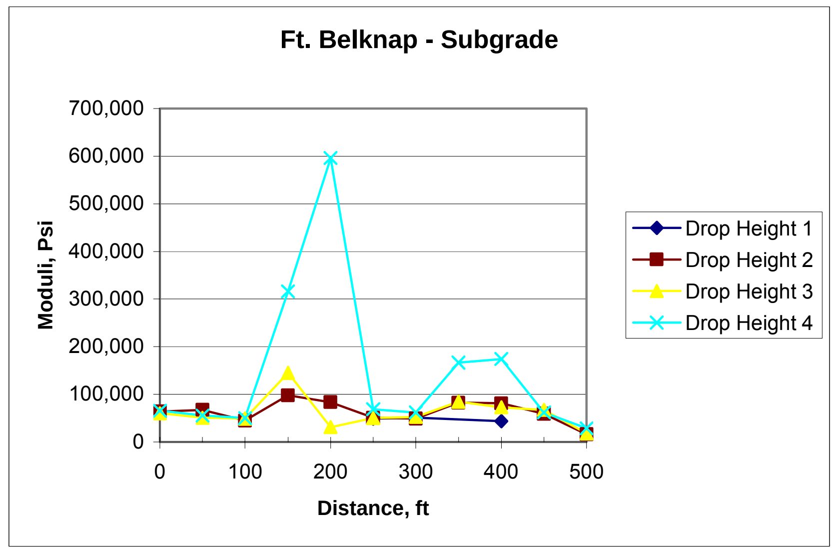


Round 2 Testing

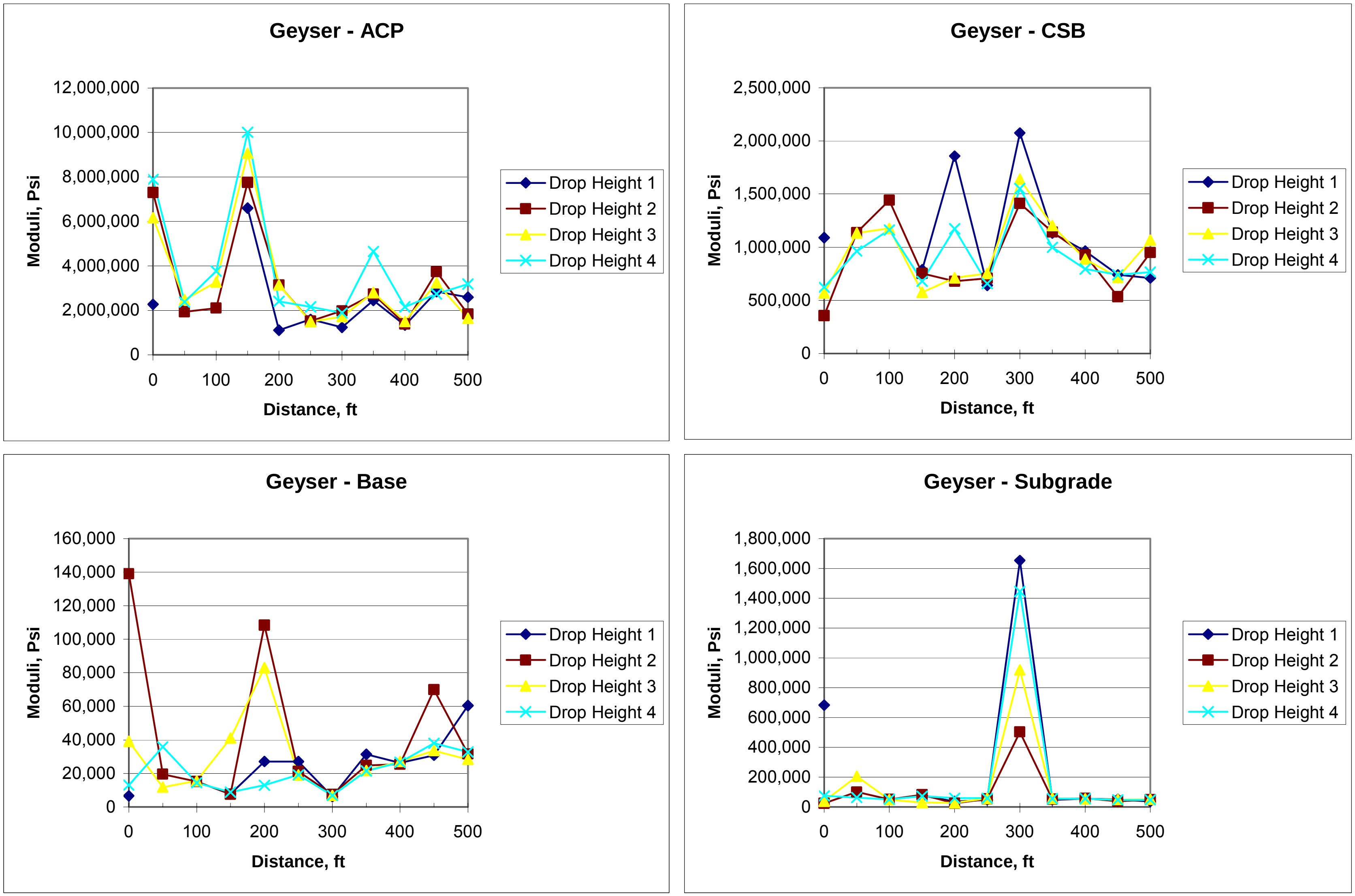




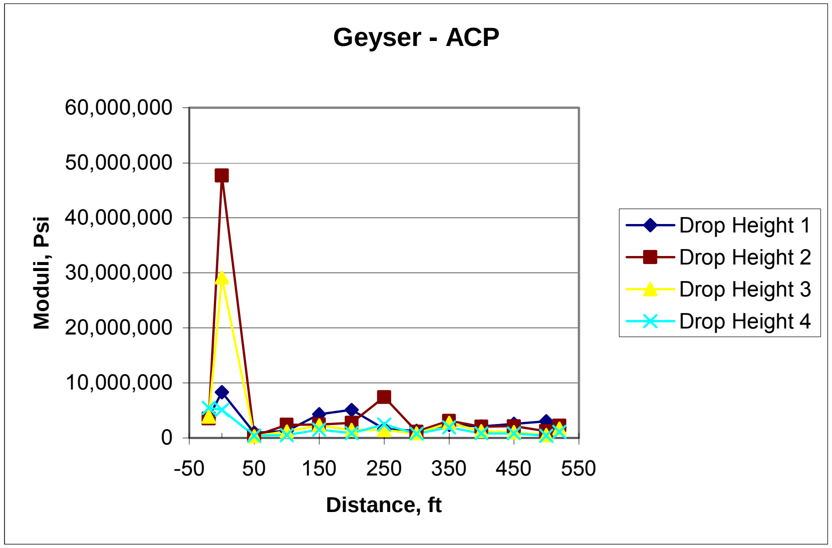


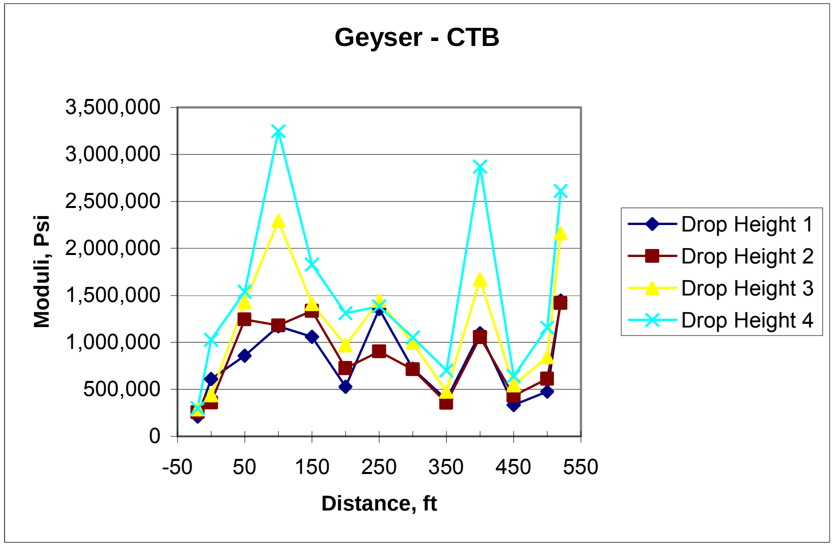


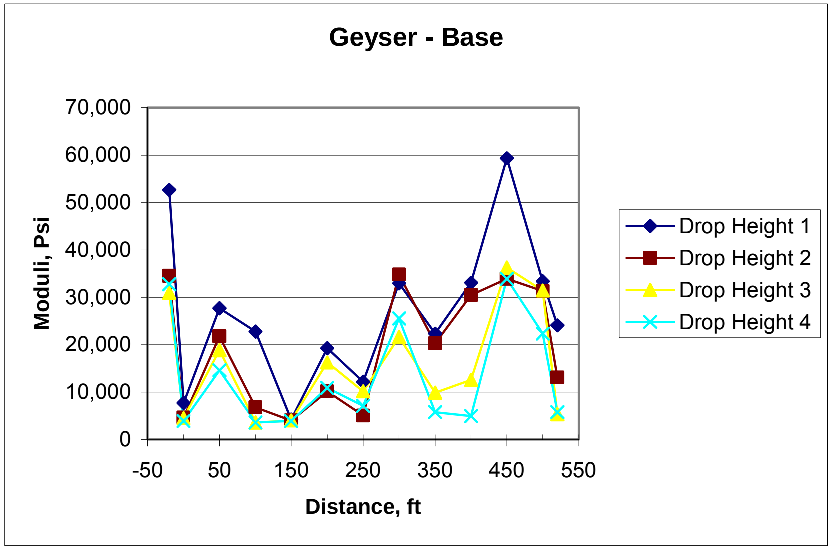
Round 1 Testing

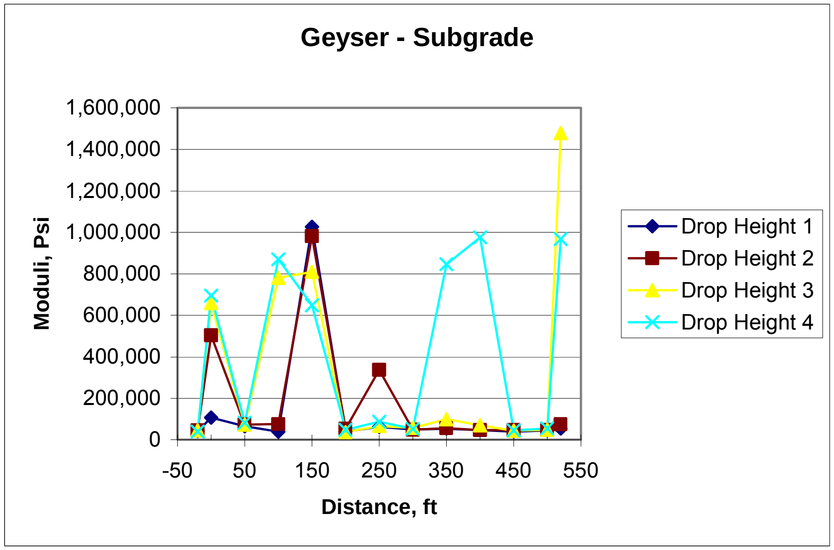


Round 2 Testing

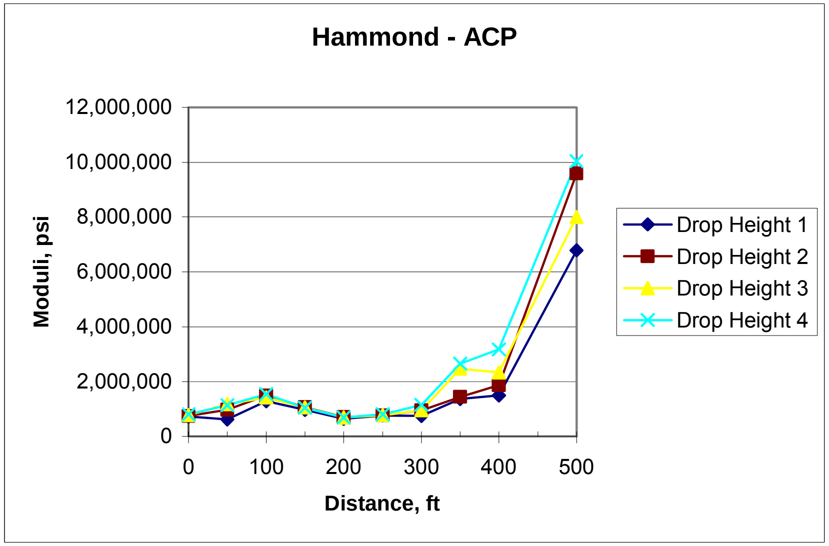


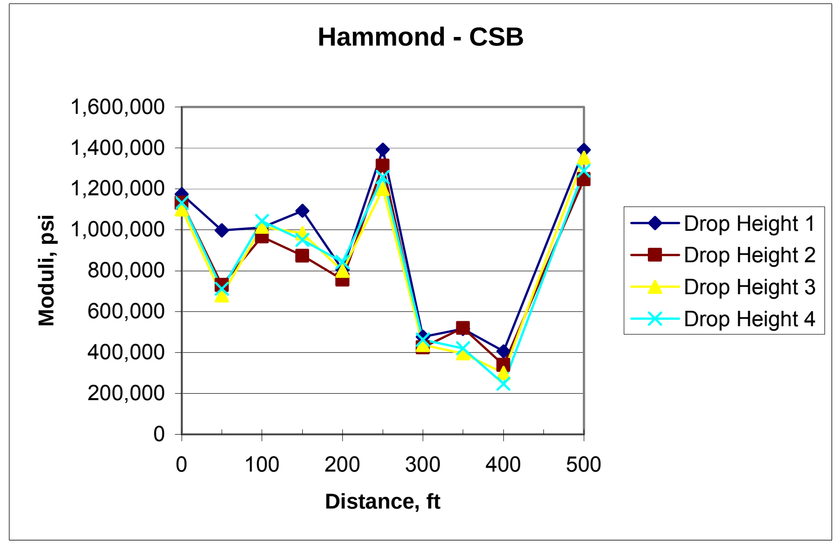


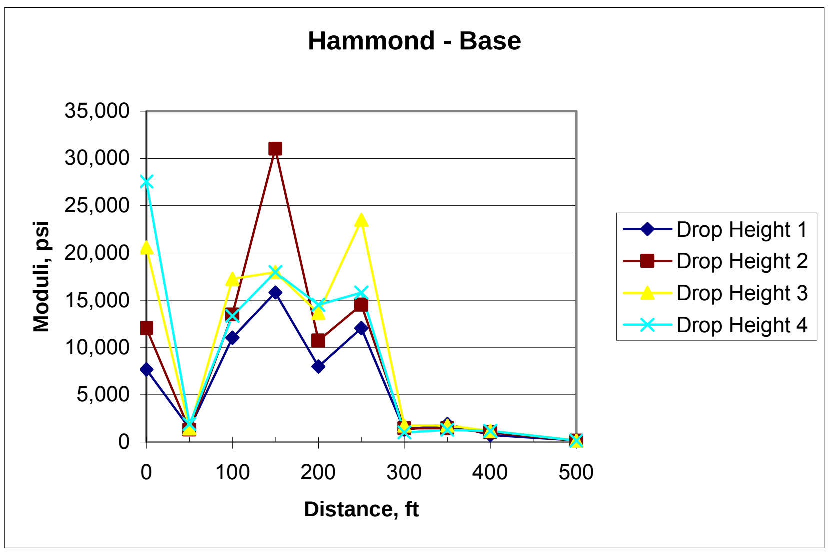


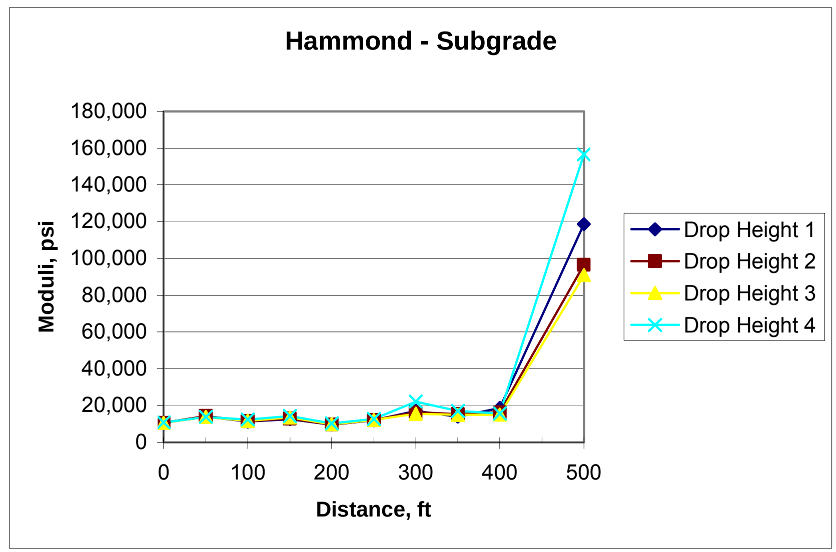


Round 1 Testing

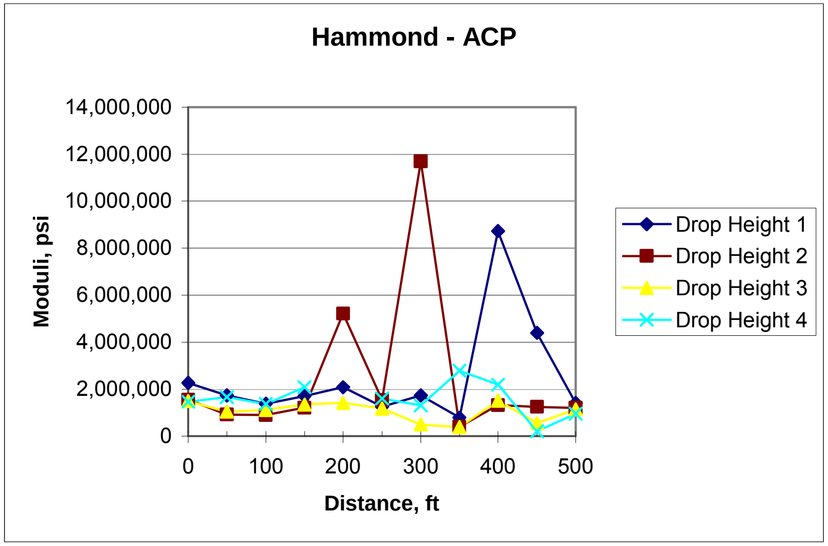


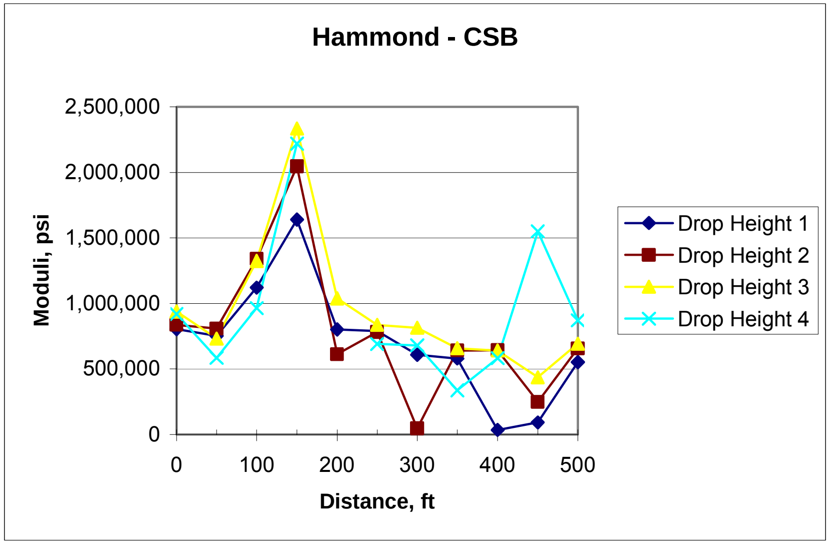


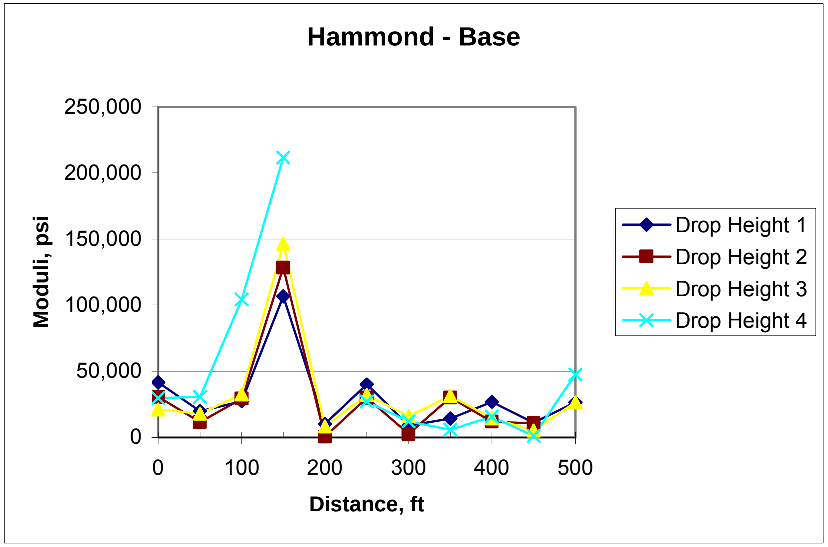


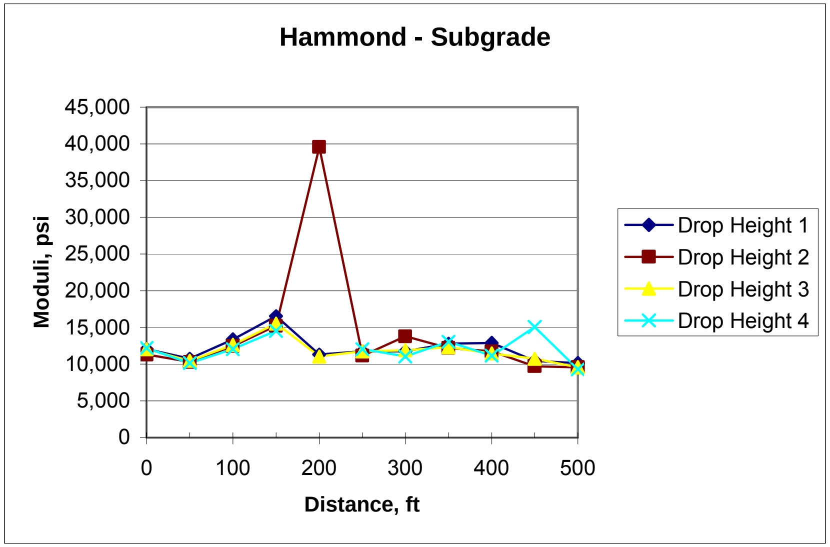


Round 2 Testing

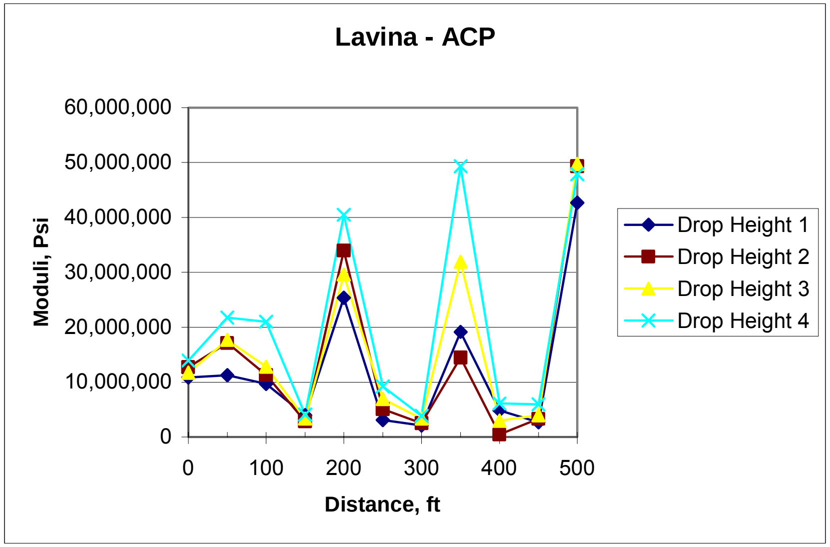


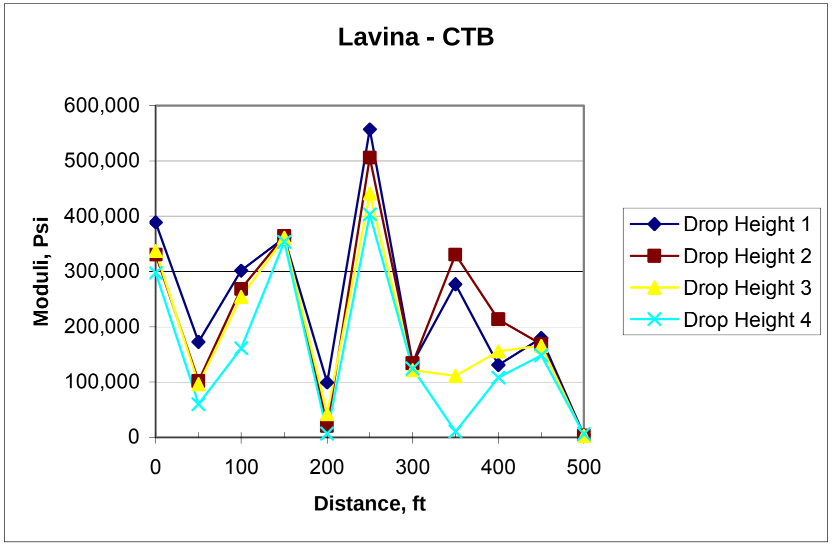




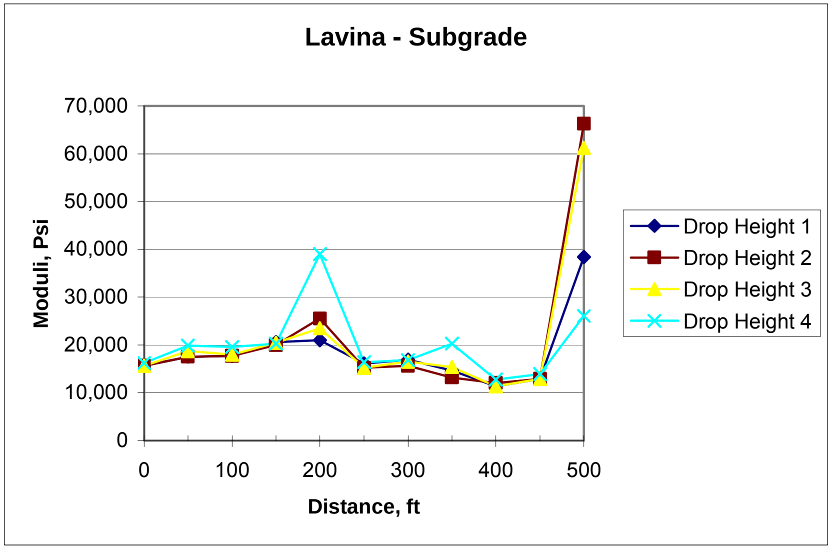


Round 1 Testing

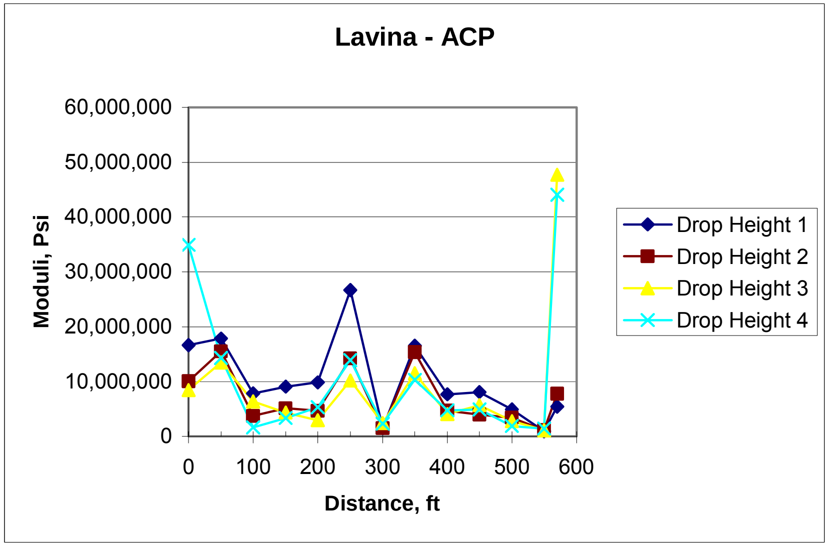


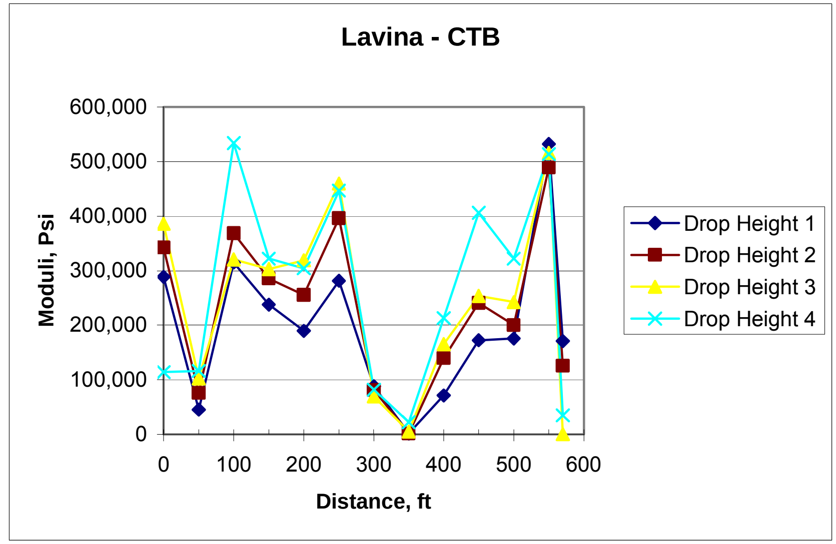


No Subbase in Pavement Structure

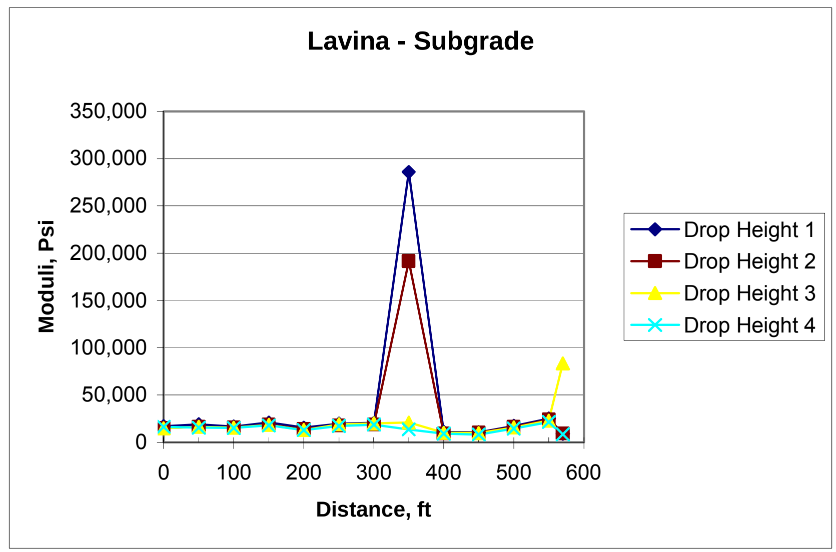


Round 2 Testing

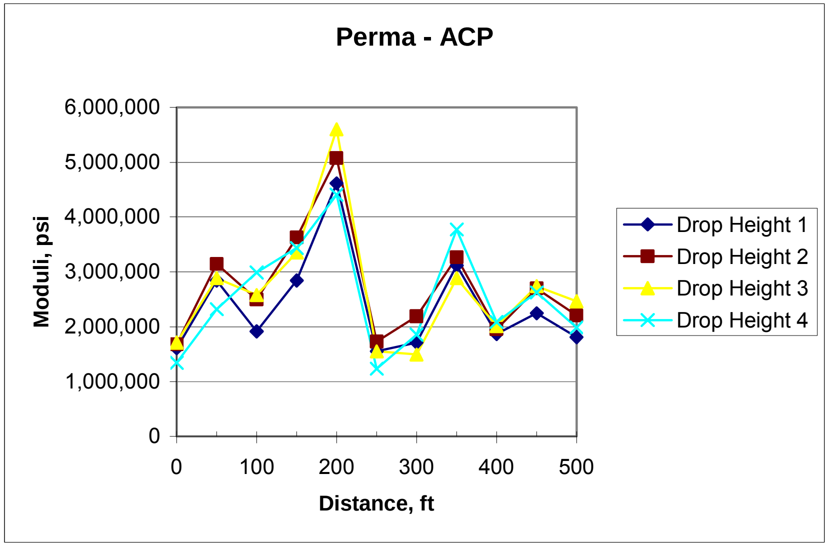


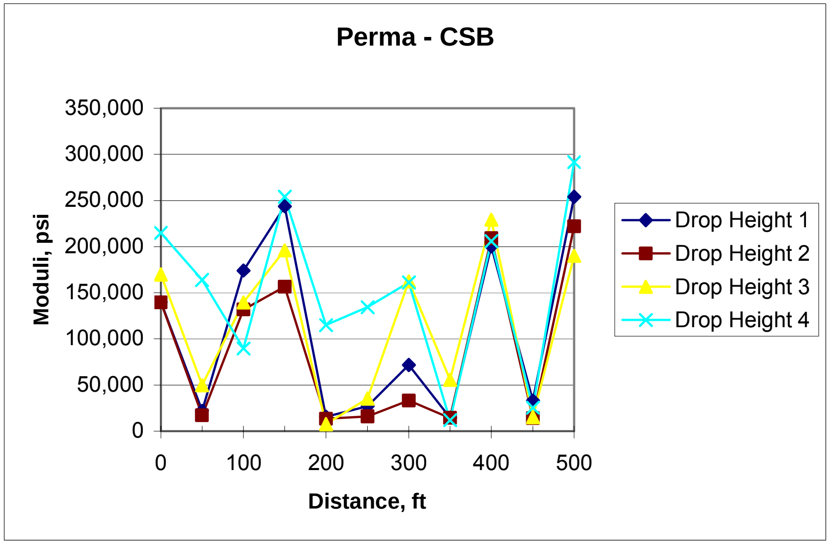


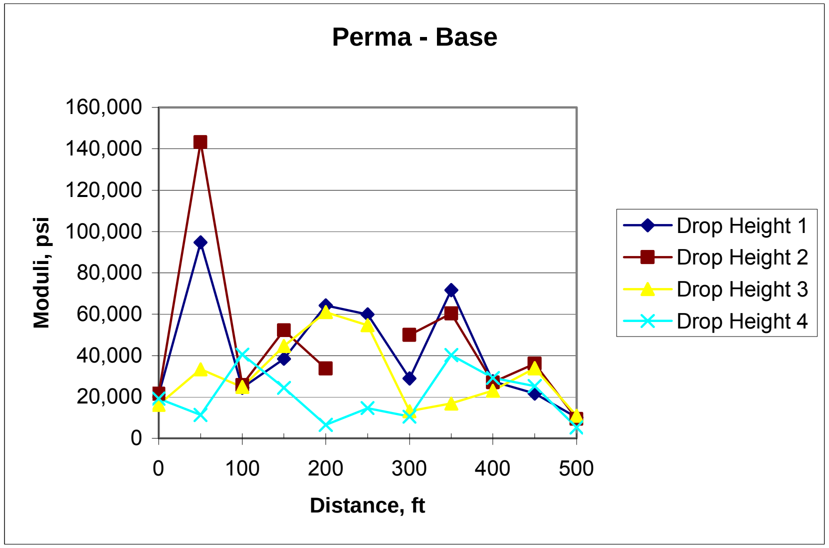
No Subbase in Pavement Structure

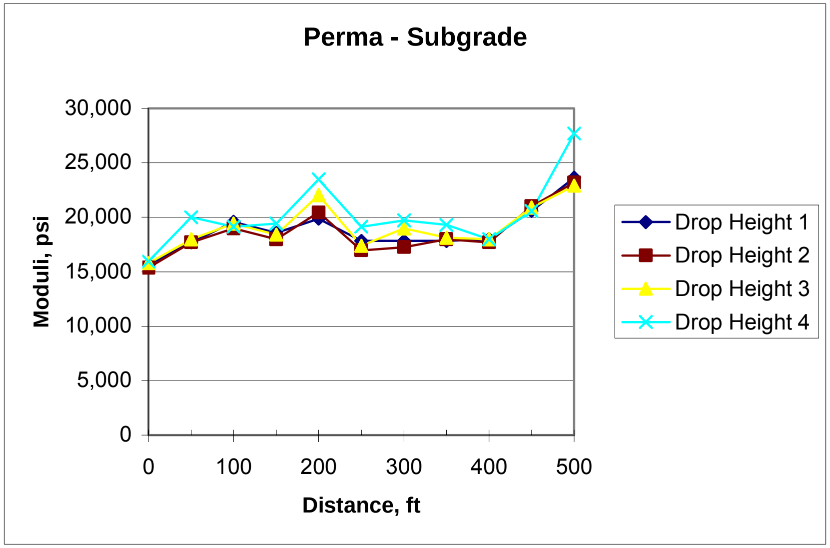


Round 1 Testing

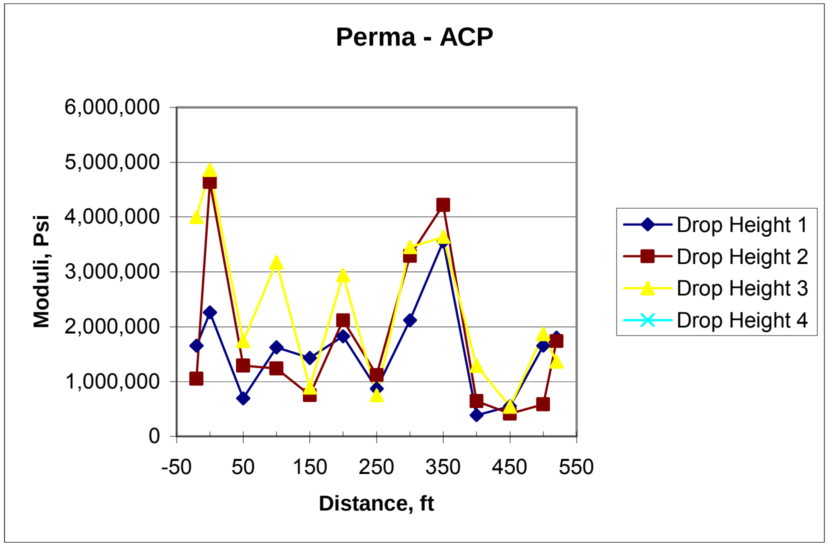


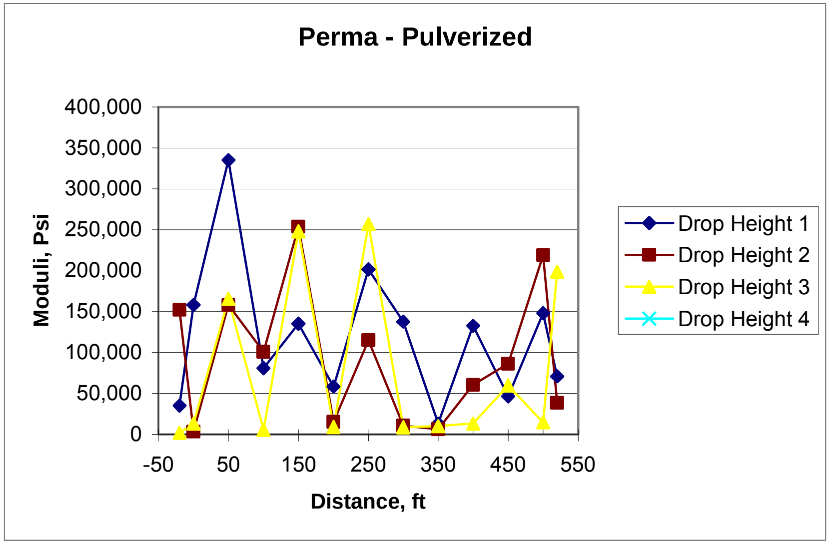


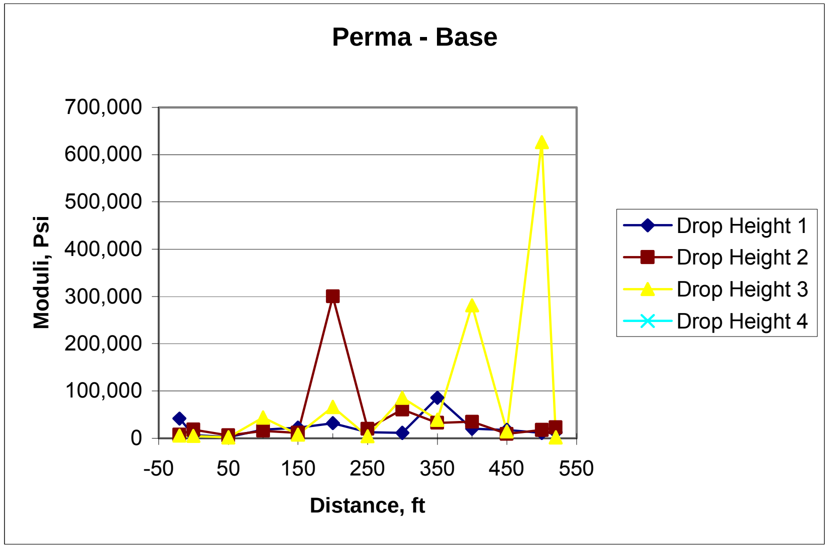


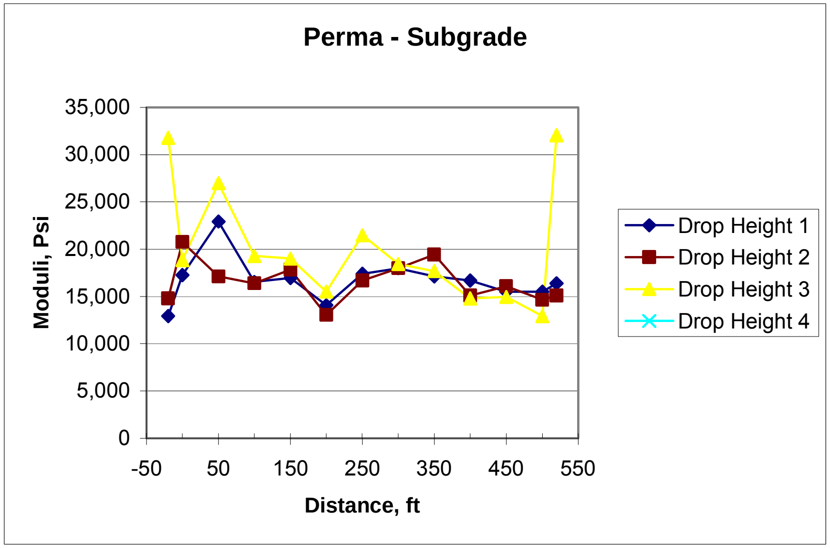


Round 2 Testing

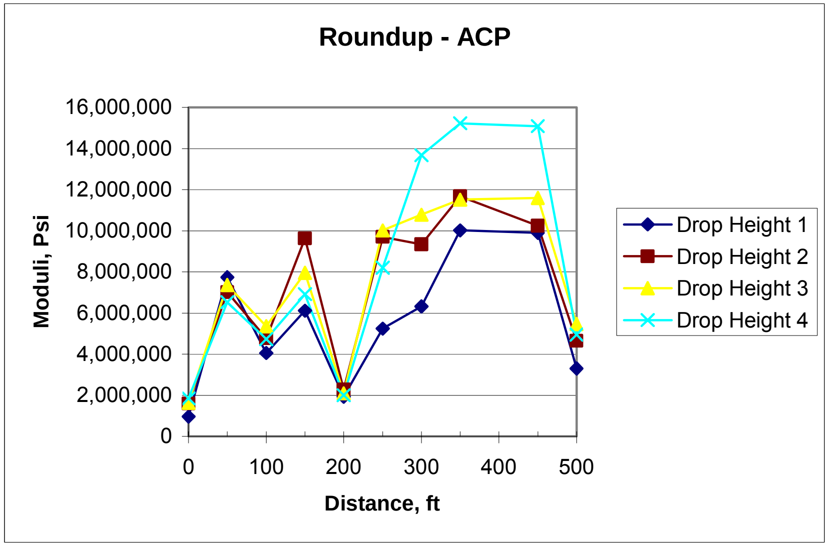


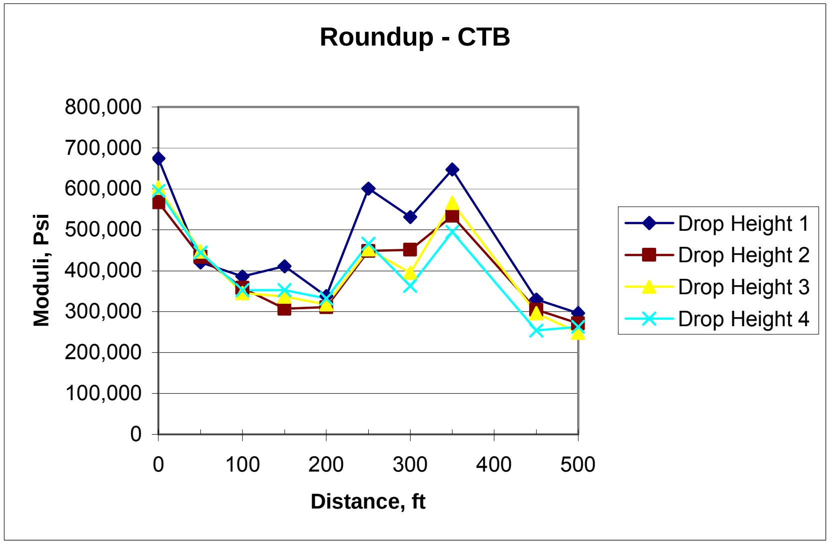




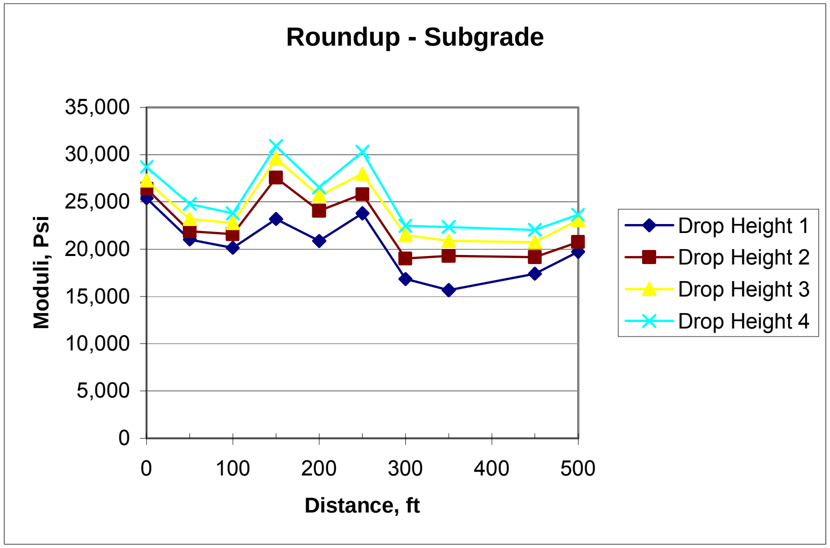


Round 1 Testing

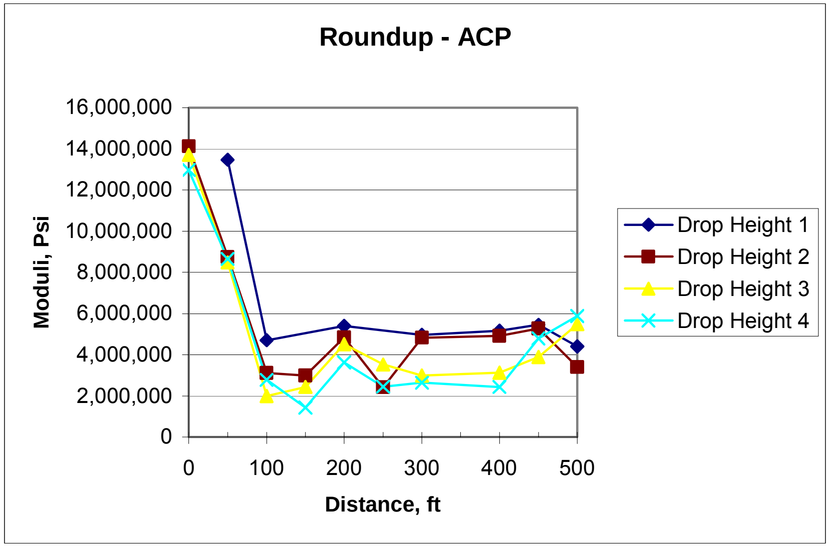


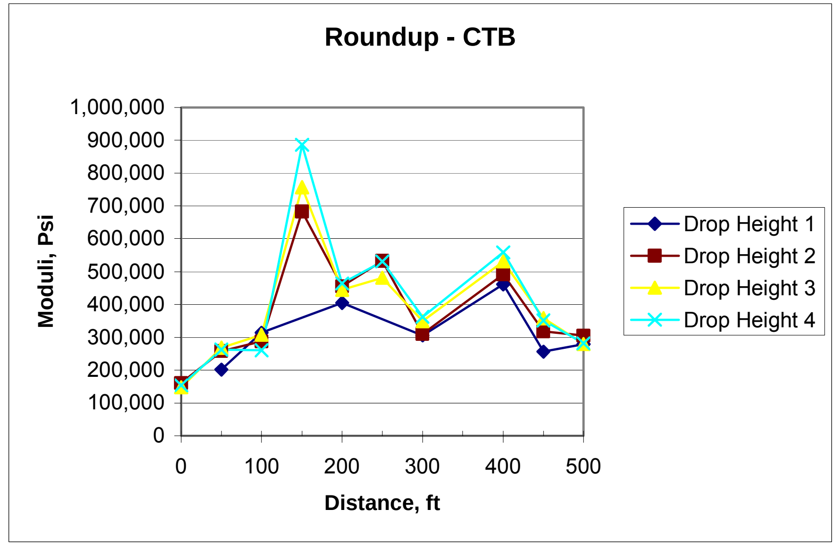


No Subbase in Pavement Structure

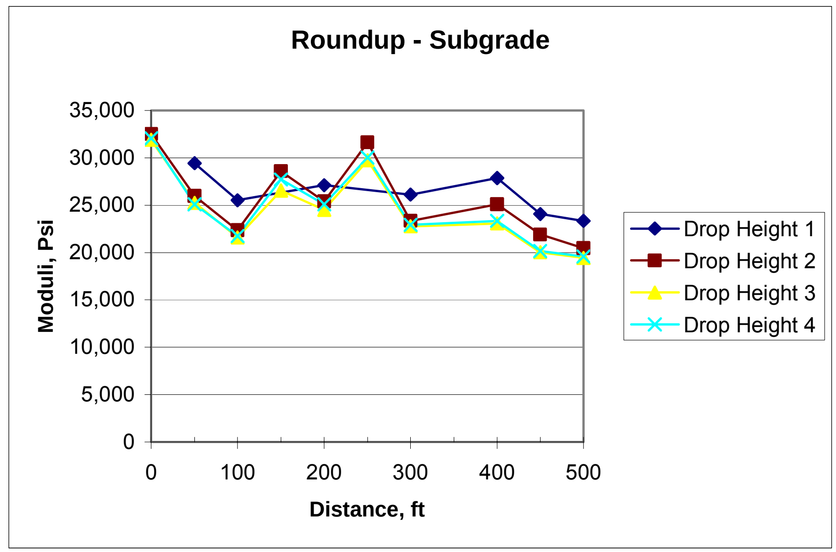


Round 2 Testing

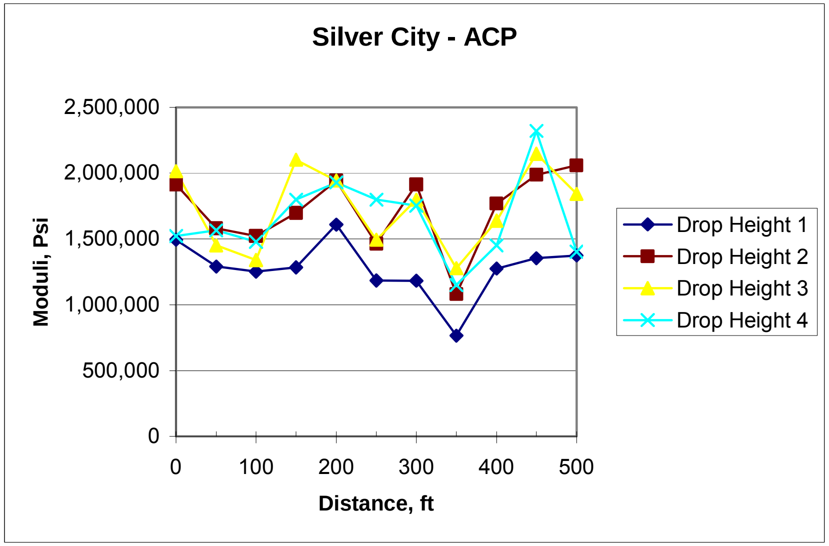


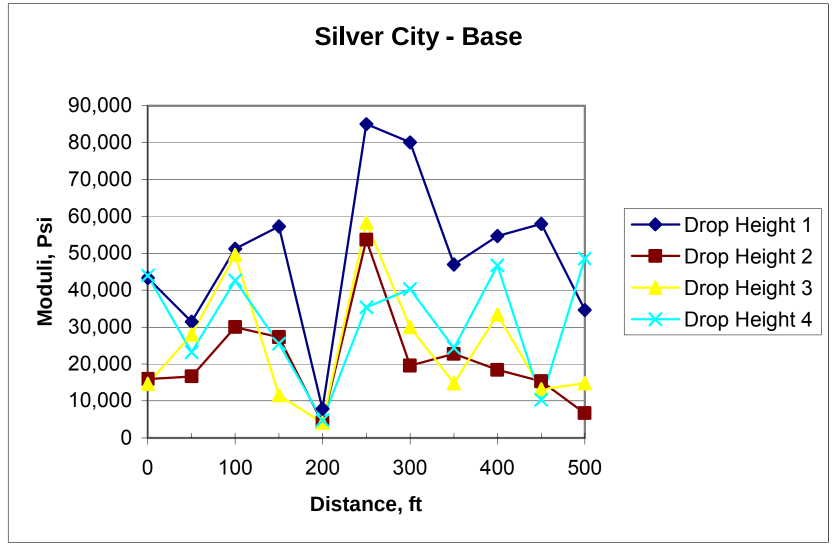


No Subbase in Pavement Structure

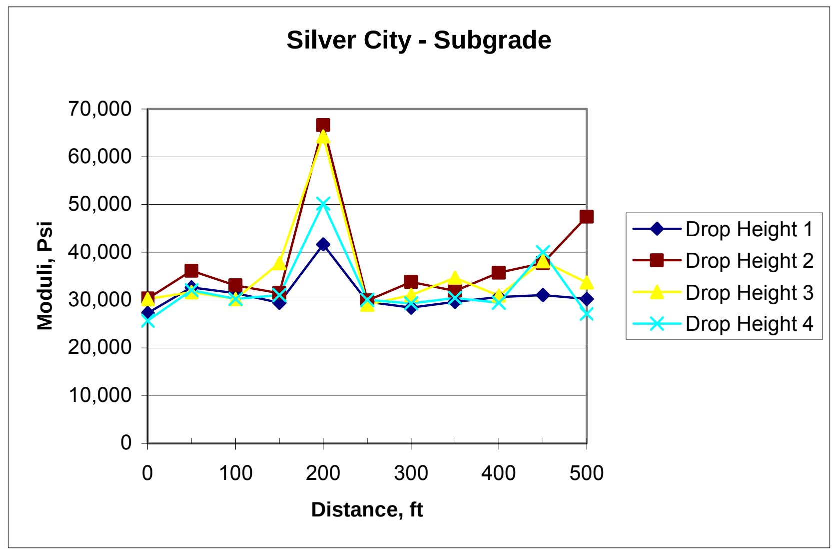


Round 1 Testing

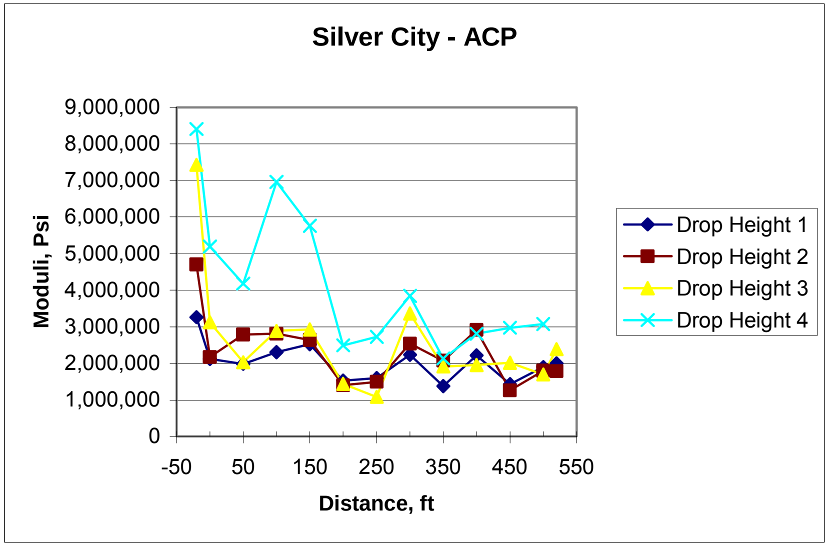


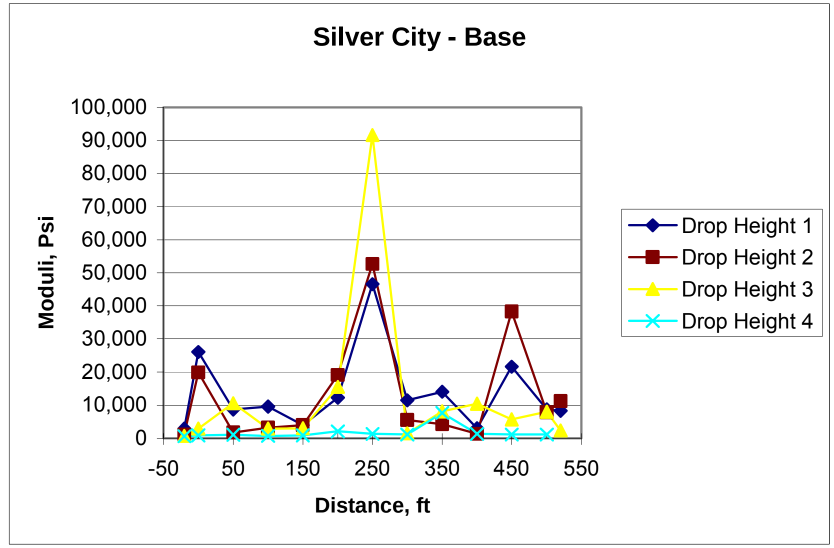


No Subbase in Pavement Structure

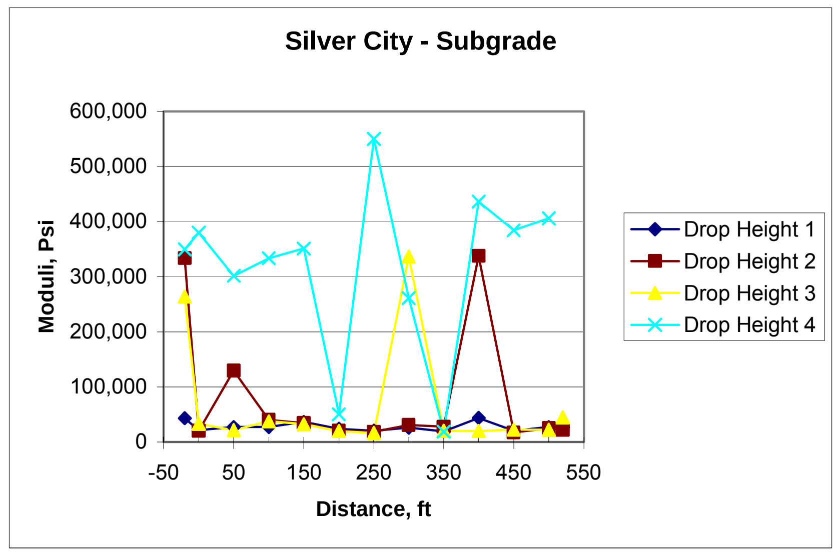


Round 2 Testing

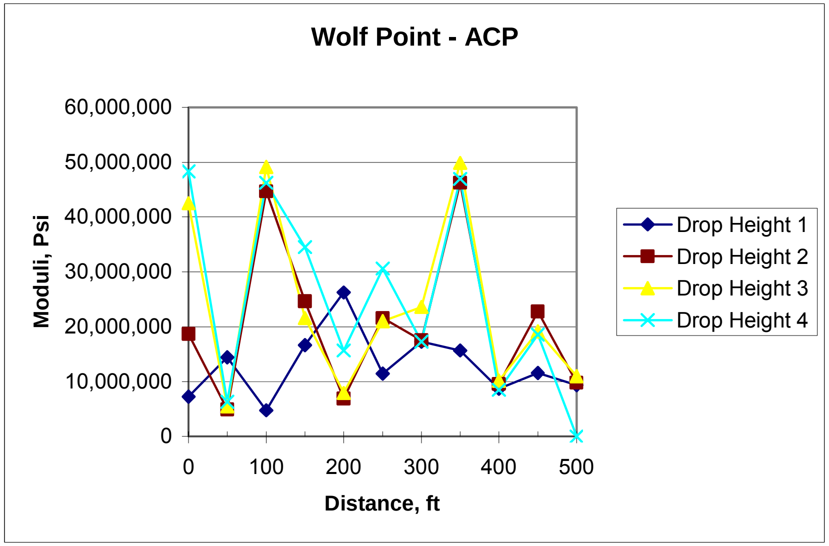


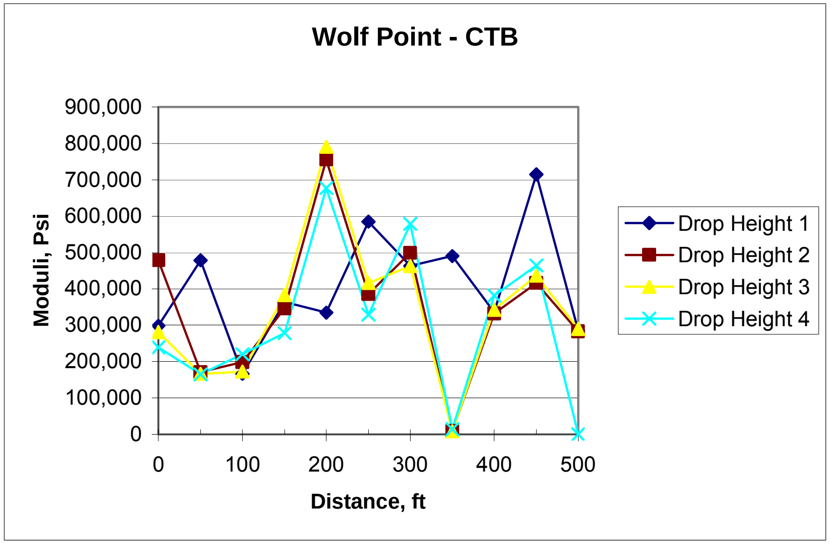


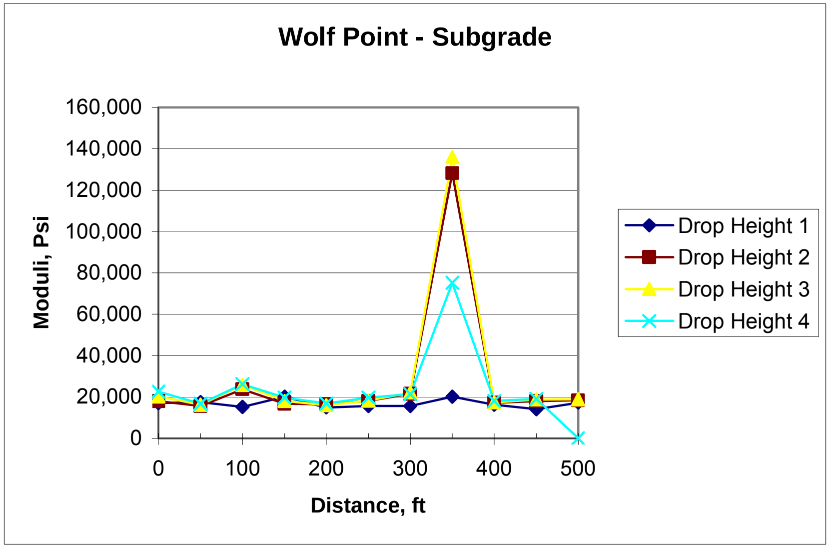
No Subbase in Pavement Structure



Round 1 Testing







Round 2 Testing